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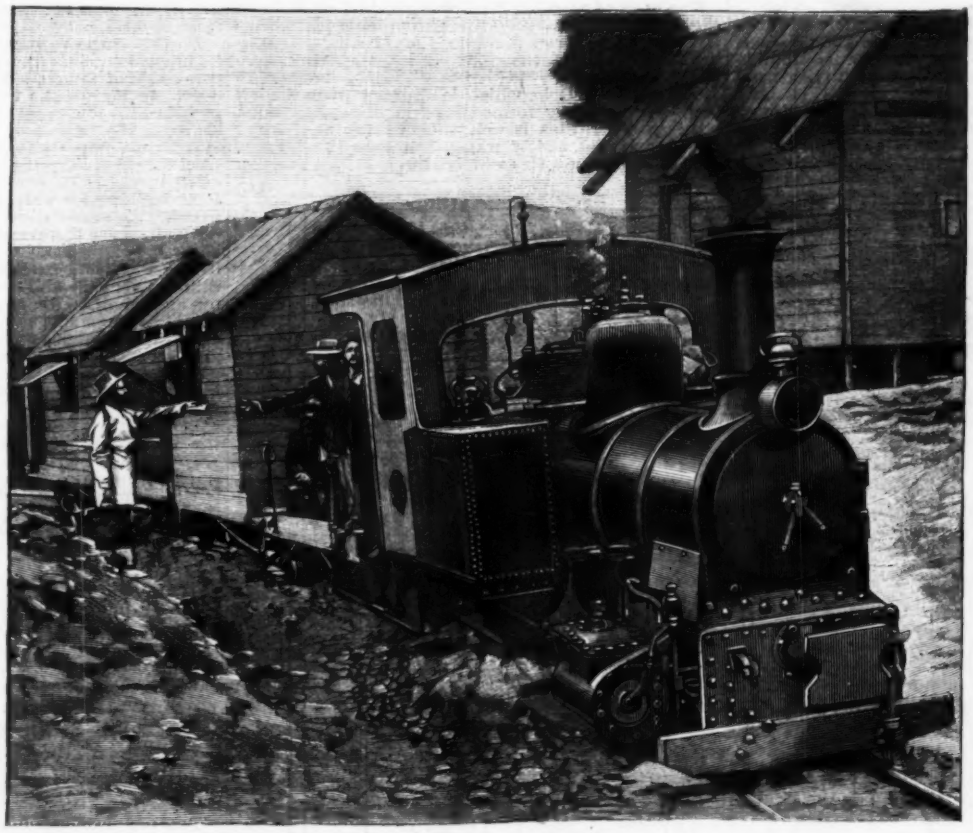
THE CONGO RAILROAD.

THE recent inauguration of the Congo Railroad was an important event in the history of Africa. Although this railroad is not over 240 miles in length, its importance is nevertheless equal to that of the Transsiberian, which is more than 4,000 miles long. It opens to the activity, enterprise, and commerce of European nations access to an immense territory that constitutes as it were a second continent within that of Africa.

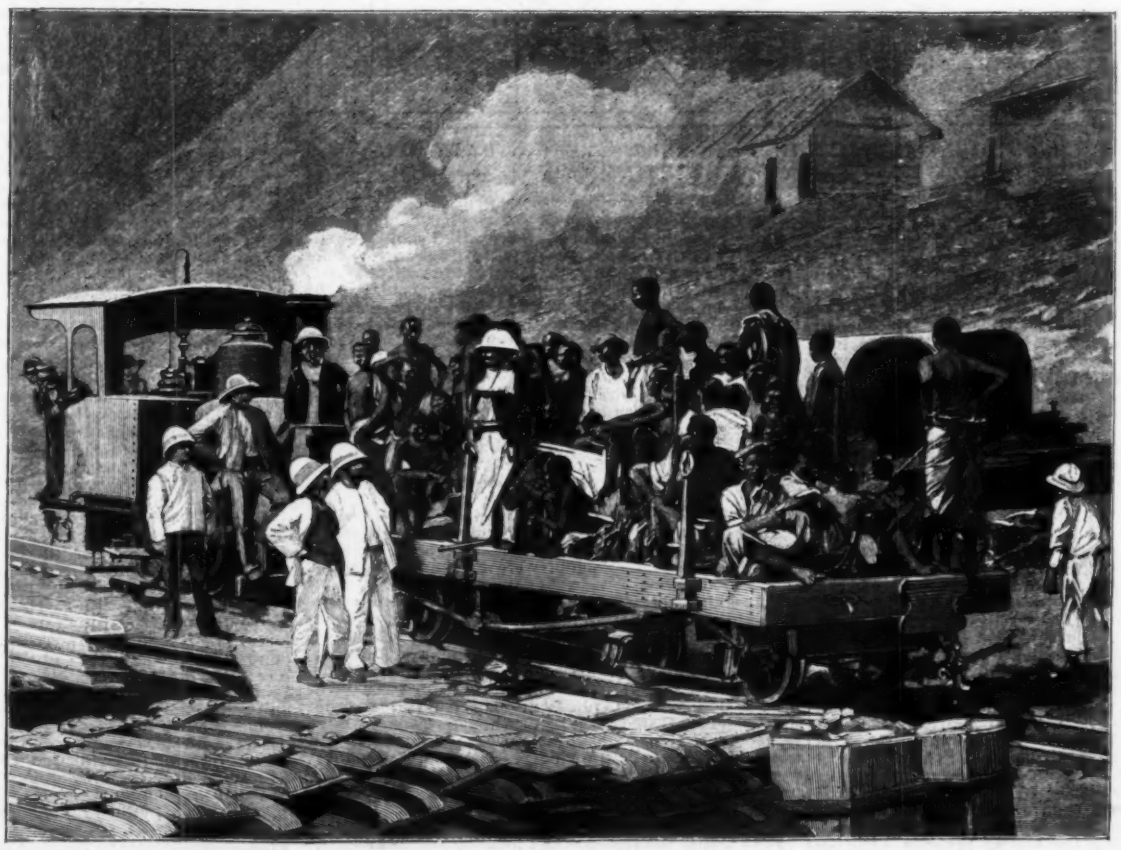
The basin of the Congo has been compared by geologists to the dried-up bed of an interior sea. To the geographer it is a real sea, and a navigable one, which washes 21,600 miles of a rich coast.

From Stanley Pool to Stanley Falls the Congo River is navigable for large steamers for a length of 960 miles without interruption, and in places is from 14 to 20 miles in width. One of its affluents, the Kassaï, which is prolonged by the Loukenie, the Sankourou, the Djouma, and the Louloua, presents a free waterway of 1,800 miles. Another one, the Oubanghi, is accessible to steamers for more than 600 miles. As a total, if we reckon all the tributaries, we have no less than 10,800 miles of fluviatile routes, say 25,000 miles of shores adapted for the landing and shipping of merchandise. Below Stanley Pool there is an end to the navigability of the Congo, which descends rapidly through cataracts from the African plateau to the coast line. Between the ocean, the great route that puts Europe and Western Africa in connection, and the wonderful system of navigable rivers of which we have just given an idea, there exists a break of 180 miles, a barrier of mountainous country. Through this region there was no other way of communication than a portage, a mere footpath for uniting the seas, and merchandise unloaded from the fleets of the Atlantic had to be carried to the Upper Congo upon the shoulders of negroes.

As the canalization of the river or the establishment of a lateral canal in the zone of the cataracts was impracticable, the construction of a railway became imperative. Stanley, after his exploration of the basin of the Congo, was the first to conclude that such a railway was necessary in order to assure the economical development of the great African state, and his conception is now realized. The railway exists, and, as regards the Congo and its navigable tributaries, is ready to play the same role as the Suez Canal does with regard to the Indian Sea.



CONSTRUCTION TRAIN CARRYING THE DWELLINGS OF THE EUROPEAN PERSONNEL.



DEPARTURE OF A TRAIN CARRYING THE LABORERS.

It was in 1885 that Stanley published his book entitled "Five Years in the Congo," and which ended in about these terms: "There is here enormous wealth which awaits a railway for gathering it. I apprise commerce of this fact and am persuaded that the notification will not go unheeded." This appeal had scarcely been heard, when a powerful English syndicate asked of the independent state a concession for the construction of a railway to the cataracts.

The proposition was received in Belgium without any enthusiasm, and the negotiations were protracted. Lieut.-Col. Albert Thys took the initiative of bringing together a certain number of persons of the commercial, financial, industrial, and political world of Belgium, and, after obtaining from King Leopold the promise that he would discountenance the English syndicate, undertook to form a society with a view to pursuing the study and eventually to constructing the railway. His efforts were successful, and on February 9, 1887, the Congo Company for Commerce and Industry was organized. On May 8, 1887, Lieut.-Col. Thys and twelve engineers started for the Congo. On the 4th of November, 1888, the studies were finished, and Lieut.-Col. Thys brought to Europe the results of a survey of 260 miles between Matadi, upon the Lower Congo, and Dolo, upon Stanley Pool. In 1889 appeared the Brochure Blache, which contained a general exposé of the enterprise.

The conclusion was that a capital of 25,000,000 francs would suffice for constructing the road, buying the rolling stock, paying the general expenses, etc. The cost of exploitation estimated was 1,200,000 francs a year. Adding this sum to the 1,250,000 francs necessary for paying 5 per cent. on the capital, it was found that 2,450,000 francs of annual receipts would be sufficient to make the scheme remunerative.

It was upon such a basis that, on July 31, 1889, was organized the Congo Railroad Company, with a capital of 25,000,000 francs, 10,000,000 of which were subscribed for by the Belgian government.

The installations of the port and station of Matadi were begun five months afterward, and in the month of March, 1890, labor on the earthwork was entered upon.

It was not till March 18, 1898, that a locomotive reached Stanley Pool. The railway, which was

finished only at the end of eight years, instead of four, cost 60,000,000, instead of 25,000,000.

The first blows of the pick were given near the Matadi station along about the first of March, 1890. The working force, which was quite inadequate, consisted then of 561 men of Sierra Leone, Krooboy and Haoussa, 36 of Senegal, and 200 of Zanzibar, supplemented by bosses and artisans of various nationalities recruited in Europe.

On leaving the station it was found there was a point projecting into the river which it was necessary for the railroad to cross in order to reach the Col des Plantations. The cutting of a passage through this neck was the first work of any importance that was undertaken. After this the line descends the counterfort and enters the valley of the Leopold ravine, through which, in the rainy season, the water rushes with great violence. The railway might have crossed this ravine and reached the opposite bank without a detour; but this would have necessitated a bridge of a single span of 1,960 feet at a considerable height above the bed of the stream. It was to avoid this that the line here forms a loop.

Up to the confluence of the Mpozo, the road runs along the steep sides of the river at a height of about 100 feet. From the first to the fourth mile, the line runs around the abrupt mountain in order to reach the valley of the Mpozo.

After this, numerous difficulties in the way of construction were encountered and put the engineers in a bad plight. More than two years after the first blows of the pick had been struck, only 5½ miles of rails had been laid, and nearly half the capital had been expended.

Moreover, although the principal obstacle had been surmounted, and the line had now left behind it the rock mass of Matadi, there now presented itself that of Palabala, which it was necessary to scale. In order to pass from 85 feet altitude of Matadi to the 1,030 feet of Stanley Pool, the railway had, in fact, to cross a ridge of 2,400 feet. The neck of Palabala was the first to be crossed. It was in June, 1892, that the laborers began on the sixth mile at the slope of Palabala.

The engineers remember this passage as one of the most troublesome of all those that presented themselves upon the route. Upon the declivities covered with quartzite, which constantly gave way under their feet, they were obliged to form a footpath in the solid rock. At every half mile there presented themselves secondary ravines (such as those of Chutet Sommeil) over which it became necessary to throw large bridges.

Through the whole extent of the Palabala, the line winds its way along escarpments that dominate the Ravin du Diable. It is a true tropical Switzerland. Finally, at the beginning of 1893, the neck of Palabala was reached. After this, the work became easier, while the sanitary situation improved. The plains of Duisi and Lufu were incomparably more healthy than the flats of Mpozo.

At the end of 1893, the first section of the line, running from Matadi to Keuge, and comprising 26 miles, was inaugurated. The fiftieth mile was reached in 1894, and the eighty-fifth in 1895. After this the rate of progress was 36 miles a year, and every year saw a decrease in the cost per mile of track.

In 1896, the road had been constructed as far as to Kimpese (96 miles).

It was after crossing the Congo River, a little beyond the important station of Tumba (112 miles), that the railroad met the third great obstacle of the direction line—the mountain of Zona Congo, a section of the ridge that bounds the ancient basin of the interior sea of equatorial Africa. But the black laborers were now numerous and experienced, and Zona Congo, the rocks of which are almost as hard as those of Palabala, was quickly scaled. The engineers were hastening toward the goal; but a little too quickly, perhaps. From the one hundred and twenty-sixth to the one hundred and thirty-first mile the road was passably established. During the rainy season that followed the construction landslides occurred that carried away the ballast and bent the rails. It was necessary to do the work all over again; but, no matter, the locomotive had passed. In the month of January, 1897, the road had reached the altitude of 2,400 feet, the highest of the entire line. Finally, the last campaign surpassed all the preceding in celerity. The end of the rail crossed the bridge of Inkisi in May, 1897, and Mount Tampa in September. In the month of January, 1898, in following the narrow valley of Lukaya, it entered the plain of the Pool.

The bank of Stanley Pool was reached at Dolo on the 16th of March last by the triumphant locomotive that had started from Matadi eight years before. During the last part of the work six miles of track were laid every month.

The village of Dolo, which is situated upon the left bank of the estuary formed by the little river Zaka, possesses a port that is well sheltered by a group of islands and that, at low water, has a depth of 16 feet. It is probable that this will be the principal starting point for steamers bound upstream. From here a branch will extend to Leopoldville. The road will curve toward the northwest and then toward the west, parallel with the Belgian bank of Stanley Pool.

The completion of this railroad, after a hard labor of eight years, does honor to Col. Thys as well as to African labor. Without the aid of the blacks, all the efforts of the white engineers would have been in vain. Materially, the railway is almost entirely the work of these negroes, who have so long been represented as drunkards and lazy and unskillful fellows.

For eight years the force was like an army in march. At first, it was a very small army, the ranks of which were incessantly reduced. Nevertheless, new recruits filled the vacancies in measure as they occurred, and when the force reached the neck of Palabala it was 2,000 men strong.

After this it never ceased to grow. In its order of march, it had its vanguard, its center, and its rear guard. Its generals-in-chief were Engineers Espanet, Goffin, and Trouet.

The camps were shifted in measure as the operation of laying the rails progressed. When the end of the track was too far in advance, the baggage was gathered up and a movement forward was made. This was done on Sunday. The small houses of canvas and wood, which served to shelter the Europeans, were placed bodily upon platform cars coupled to the construction trains. When the new site was reached, the houses were at once so grouped as to form a picturesque little village. At a short distance were erected the wooden barracks designed for the blacks, although the latter, in most cases, preferred to construct for themselves huts of branches, foliage, and old material.

For digging the trenches and forming embankments, from Matadi as far as to the Pool, the tools employed were merely the pick and the shovel. At some points a few dynamite cartridges were used for blasting the rocks, and, at a few localities, apparatus for removing the spoil were employed.

The Congo Railway was inaugurated officially at the beginning of July. From that date commercial traffic has been utilizing the entire line.

The tariffs adopted by the company and fixed by the act of concession are very high. They nevertheless represent a notable economy as compared with the old cost of carriage by caravans across the region of the falls.

The financial prosperity of the railway is now assured, despite the increase of the capital; and it is interesting to find that, since the road was finished, the commercial movement between Stanley Pool and the mouth of the river has quadrupled. Before the establishment of the line, scarcely anything was demanded of Congo except ivory, because nothing but the latter stood the expense of portage, or rather because it was of interest to employ the latter for the most remunerative products, inasmuch as it had but a limited personnel at its disposal. In 1889, about 120 tons of ivory, forming 6,000 loads, descended toward the coast.

As soon as the railway becomes further advanced in its operations, it is thought that rubber, too, will be demanded of Congo, since the country yields this product. In measure as the provisional exploitation approaches the Pool, and in measure as the portage route shortens, the descent of rubber toward Matadi is increasing in importance. In 1896, 1,200 tons, and 1897, 1,800 tons of it were transported. In 1898, the amount carried will be 4,000 tons; and Congo will doubtless soon become, for this product, the supplier of the world, which annually consumes 52,000 tons.

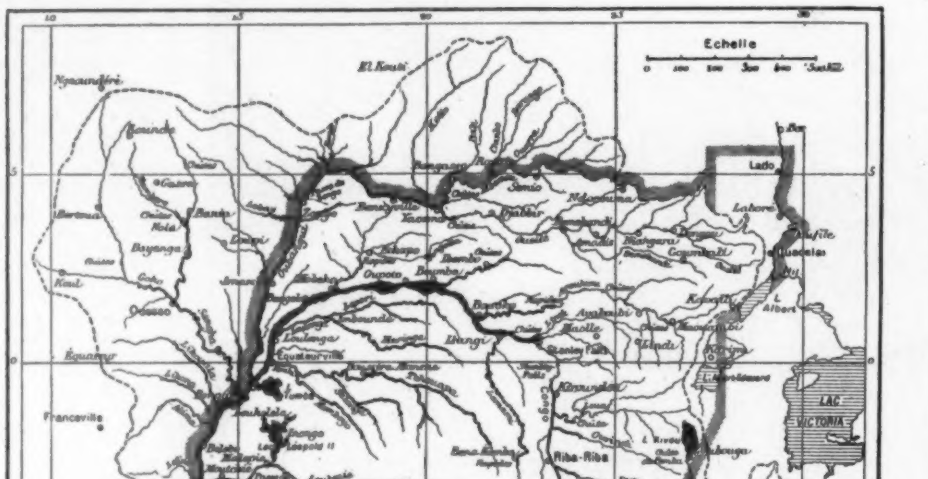
All along the 21,000 miles of river shore of the Congo basin only four men per mile went daily into the neighboring forests to gather, each of them, 4½ pounds of rubber. Per mile and per year, that would be about a ton and a half, and for the 21,000 miles, 48,000 tons.

After ivory and rubber will come agricultural products. All that may be demanded of her, Congo will give: coffee, cacao, oleaginous products, cereals, etc.

As the differential tariffs of the railway affect every kind of merchandise descending proportionally to its value in the markets of Europe, the products of secondary value will be permitted to enter rapidly into the commercial movement.

The railway will transport, and, in fact, is already transporting into the interior, in addition to the imported European goods demanded by the natives and the colonists, the equipments indispensable for the economic development of the country: boats, agricultural and industrial machinery, tools, etc., and, in a word, everything that is wanting in Congo.

For the shipment and reception of merchandise Brazzaville is almost as advantageously situated at the terminus of the line as is Leopoldville. There is no reason, then, why French Congo, which borders upon the independent state, should not share in the same benefits. For the above particulars and the accompanying engravings we are indebted to L'Illustration.



MAP OF THE CONGO BASIN AND OF THE NAVIGABLE STREAMS THAT WILL SUPPLY TRAFFIC FOR THE NEW RAILWAY.

(The heavy lines indicate the navigable portions, and the shading shows the boundaries of Belgian Congo.)

HIGH EXPLOSIVES AND SMOKELESS POWDERS AND THEIR APPLICATIONS IN WARFARE.

By HUDSON MAXIM.*

THE popular idea of an explosive is something which will burn up instantaneously without requiring air to support its combustion, and which may, therefore, be fired in a confined space.

It is hard to dissociate the idea of explosion from that of instantaneous reaction. Yet the differences in the time required for the consumption of various explosive bodies, although too insignificant for measurement by our senses, have a very great significance in their applications, especially as gunpowder.

Small fractions of a second become very important factors in controlling and directing explosive energy, especially in the attainment of high ballistics in guns.

Explosive compounds are burned in two ways, one by combustion from surfaces exposed to a consuming flame, the other by what is called detonation, by which the explosive is consumed nearly simultaneously throughout its mass by a wave action.

Combustion from surfaces requiring an appreciable time for the consumption of the explosive body adapts it to use as a gunpowder. The detonative form of explosion adapts a body to shattering or disruptive purposes, and unfits it as a gunpowder. The latter are termed high explosives. However, the function of an explosive, whether as a combustive or a detonative compound, is very largely determined by its physical character, temperature, and the conditions of confinement under which it is fired.

By making an explosive compound dense and hard, its susceptibility to detonative influences is lessened, owing to the increased work imposed upon the reaction in overcoming the force of cohesion. Similarly, the adulteration of an explosive body with another and non-explosive body lessens its susceptibility to detonative influences, owing to the energy required in breaking up the foreign body.

It is well known that guncotton can be ignited in considerable quantity and burned quietly away without detonation. If, however, a sufficiently large mass be fired, the localization of heat and pressure upon the surface of the burning body, owing to the energy required to displace the products of combustion as fast as set free, will cause the whole mass to detonate. In this instance the heat and pressure of the products of combustion upon the surface of the burning explosive perform the function of a detonator or exploder, like fulminate of mercury.

The reason why fulminate of mercury is such a powerful self-detonative body is owing not only to the weakness of the chemical bond between the molecules of its constituents, but owing as well to the high specific gravity and density of its products of combustion and their confining or tamping influence.

Nitroglycerin, in small quantities, may be burned like an oil, and even fulminate of mercury may be burned in a vacuum without detonation. Nitrogelatin, the most powerful commercial high explosive

* Lecture delivered before the Franklin Institute, Philadelphia, on Tuesday, September 20.

known, may even be used as gunpowder in small quantities and under light confinement.

Fibrous guncotton, which consists of an infinite number of small tubes, whose walls, although of a dense colloid, are very thin, owes the facility with which it can be detonated to the fine state of division of this colloid.

If guncotton be dissolved in acetone, poured on a plate of glass and dried, it is well known how the hard and hornlike product resists detonative influences. However, if reduced to a fine powder, its susceptibility to detonation is restored, or, if redissolved in acetone and poured into water in a fine stream, a fluffy, fibrous material is formed, resembling very closely the original fibrous guncotton, and which will detonate with equal ease and violence.

Cordite, the smokeless powder at present used in England, consists of fifty-eight per cent. nitroglycerin combined with thirty-eight per cent. guncotton and four per cent. mineral jelly, which ingredients, if simply mixed together or mechanically combined by absorbing the nitroglycerin in the guncotton, would make a very high grade dynamite. In fact, it would be one of the most violent high explosives known. But in the manufacture of cordite, the guncotton is dissolved in a volatile solvent, such as acetone, which is afterward evaporated out, the nitroglycerin being added to the guncotton while the same is in solution, the resulting compound being, when dry, an elastic and rubbery body.

The nitroglycerin in cordite is still, however, only mechanically combined with the guncotton, and the guncotton colloid holds the nitroglycerin in its pores in the form of minute particles or drops, similar to the manner in which water is held in the pores of a sponge, except the guncotton sponge is very much denser and of very much finer texture, the density and tenacity of the sponge serving as a sufficient barrier to detonation to permit of the use of the compound as gunpowder.

Cannon powder is not a powder at all. The term powder in this application is a misnomer. Explosive compounds employed as propelling agents for throwing projectiles from guns, instead of being in pulverulent form, consist, on the contrary, of large grains or pieces of solid material, varying from a quarter of an inch to more than an inch and a half in thickness, and sometimes, as in the case of cordite, big sticks of explosive material are employed eighteen inches or more in length.

Originally, however, gunpowder was actually made in the form of a powder, being a loose, mechanical mixture of sulphur, saltpeter, and charcoal, and which, although it did not detonate in the gun, was still completely consumed before the projectile had moved its length; consequently, charges could not be employed large enough to impart high velocities to projectiles without giving excessive initial pressure.

It was found that, by compressing the explosive mixture into dense and hard cakes, and then breaking them up into grains, more time was required for combustion by the flame being to some extent localized or confined to the surfaces of the grains, so that the gases, instead of being all set free at once, their evolution was made to consume sufficient time to permit of the projectile being displaced enough to give room behind it for the reception of the gases of the explosion before the complete consumption of the charge. However, with such powders the pressures fell off rapidly because of the diminished burning area of the grains as combustion progressed.

A powder is smokeless which leaves no ash when burned, but is converted entirely into gases. A little more than half the products of combustion of common black powder consist of solid matter or ash, and it is this solid matter which makes the smoke.

If guncotton be dissolved in a suitable solvent, like acetone, and then dried, a very hard and hornlike substance is the result, which may be cut up into grains and used as gunpowder, but this substance is so hard and so dense that grains of it have to be made quite thin, in order to secure its complete consumption in the gun, because it will not burn through a sufficient thickness before the projectile leaves the gun.

Owing to the fine granulation necessary to secure the complete consumption of a pure guncotton colloid, so much surface is presented per unit of weight as to preclude the use of sufficient charges to give requisite velocities without dangerous pressures. For this reason no pure guncotton powder, except in the form of the Maxim-Schupphaus multi-perforated grain, which will be explained further on, has yet been produced which has been successful in guns of more than four inch caliber. Even in these guns much higher ballistics are attained by multi-perforating the grains.

The addition of nitro-glycerin to a guncotton colloid in its manufacture softens the material and causes it to burn with greater rapidity, thus permitting of coarser granulation. However, in order to secure combustion through a sufficient thickness of material to adapt it for use in guns of the largest caliber, nearly sixty per cent. of nitro-glycerin is required. Such a compound is British cordite, and one too dangerously near being a detonative compound. Nevertheless, without multi-perforations, there is no other method of securing the results.

Although a charge of powder in a gun is consumed with such rapidity as to appear to our senses to be instantaneous, still it is far from being so. Although a grain of smokeless powder be consumed within one sixty-fifth of a second, still its combustion takes place entirely from the surface, and progresses with the most perfect regularity. Its combustion is similar to that of a piece of wood in the fire, only the combustion of the powder grain is infinitely more uniform.

When a rifle is placed to the shoulder and the trigger pulled, the time that elapses between the fall of the hammer and the flash at the muzzle is so brief that it appears to our senses to be perfectly instantaneous. Yet, during this time, the firing pin has moved forward and exploded the percussion cap, which, in turn, has fired the powder charge, and a certain period of time has been consumed in the combustion of the powder; the projectile has been started at first slowly and then forced along with accelerated velocity to the muzzle, and as the projectile moves away from the muzzle, the powder gases, rushing out at a much higher velocity than the projectile, impinge upon it, and are thrown outward at right angles to the gun in the form of a disk, in exactly the same manner as though the projectile were held stationary in that position. Such, in spite of the evidence of our senses, is the relativity of velocities and time.

Probably no industry has, in its evolution, exacted more of the inventor than has the production of smokeless powder. Chemistry, physics, mechanics, mathematics, and the science of gunnery, are all links in the chain upon which hangs success.

For about fifty years naval and military men have recognized the advantages of smokeless powder, provided such a compound could be practically produced. It was recognized that the absence of smoke would give to the party using it a tremendous advantage over an enemy using black powder, owing to the difficulty that would be experienced in determining the direction or source of fire where smokeless powder should be employed; while, on the other hand, smoke-producing powder would not only cause the users of it to be readily located, but would, at the same time, serve to obscure their own vision.

Not until about 1888 had anything like a practical smokeless powder compound been produced. About that time the French government had, by a secret process, developed a smokeless powder for small arms, and which was used in the Lebel rifle, the substance being known as the Lebel powder. This compound is now known to have been simply a soluble variety of guncotton dissolved in a volatile solvent and then dried in thin films or sheets and cut up into small laminæ or squares.

The Lebel powder produced a great furor in Europe at the time, and the most wonderful claims were made for it. It was at that time that I began the investigation of the subject in England, returning soon afterward to America, where I continued my work. A little later I engaged the services of Dr. Robert C. Schupphaus, who was formerly connected with the American Xylonite Company. We joined our forces and our inventions, and have been working together ever since.

Up to that time, there had not been produced any smokeless powder for large guns, and even the then much vaunted Lebel powder has since been replaced by another and superior compound.

The importance of solving the problem by the production of a successful smokeless cannon powder enlisted in the work many of the best chemists, mechanics, and scientific men through the world, many of them being backed by limitless government resources or by vast private capital.

Dr. Schupphaus and myself entered the race for the production of a successful smokeless cannon powder with the field against us. Ours was a race against the world, and we were unfortunately handicapped from want of capital and the difficulty of getting capitalists interested in a new and untried thing, and further handicapped by the dilatoriness, penuriousness, and exacting methods of our own home government.

In the face of all these difficulties and disadvantages, the Maxim-Schupphaus smokeless cannon powder has been produced, and which has given the highest ballistic results ever known.

All the most essential desiderata in a smokeless powder are its distinguishing features.

We discovered a new quality in nitrocellulose, that by mixing a small percentage of soluble pyroxylin or gelatin guncotton with tri-nitrocellulose, or high grade guncotton, the mixture could be digested and rendered plastic, and could, under heat and pressure, be moulded into grains with very much less solvent, and that the grains so produced would shrink but little in drying, and would readily take and retain the shape of the forming die in all its geometrical details; whereas high grade guncotton or tri-nitrocellulose, if used alone, could not be moulded into similar grains without warping and cracking all to pieces in drying, while soluble guncotton is not only exceedingly difficult to work by itself, but presents to a great extent the difficulties encountered in the employment of tri-nitrocellulose alone.

Our formula is an elastic one. We may either use no nitroglycerin at all or may employ any percentage to meet the requirements of ordnance boards of different governments, or we may replace nitroglycerin with an oxygen-bearing salt, such as nitrate of barium. But we prefer to employ and recommend the use of from ten to twenty-five per cent. of nitroglycerin. Such a small percentage has no disadvantages whatever, and has many advantages above a pure guncotton compound, or one containing an oxygen-bearing salt. Nitroglycerin is a compound that has been very widely misunderstood, and it is not generally known that pure nitroglycerin is even more stable, if anything, than pure guncotton, and that it will stand a higher heat test.

In the report of the Chief of Ordnance of the United States Army for 1896, page 197, after dwelling at length upon the advantages of progressive combustion due to multi-perforated grains, it is broadly stated that, "all things considered, the perforated cylinder in the Maxim-Schupphaus powder appears to be the most suitable form for the colloidal smokeless powder."

It is obvious that a powder which presents a smaller initial burning area than another, and whose area increases instead of diminishing as combustion progresses, must be subject to enormously less variations in ballistics than a powder which presents the maximum area to the ignition flame and burns with a constantly diminishing area.

The Maxim-Schupphaus smokeless powder, when compared with cordite, pound for pound, offers about one-fourth to one-fifth of the initial combustion area, and when compared with ballistite or cubical powders, it offers, pound for pound, less than one-sixth of the initial combustion area. Therefore, when equal charges are fired, under like conditions, the Maxim-Schupphaus powder will give at most not more than between one-fourth to one-fifth the variation in initial pressures that cordite gives. The same holds true for velocities, and the results of firing of our powder substantiate this claim.

One of the best and most comprehensive articles ever written on the Maxim-Schupphaus smokeless powder appeared as an editorial in London Engineering of August 20, 1897. The editor says: "The distinguishing feature of the gunpowder invented by Mr. Hudson Maxim and Dr. Schupphaus is its form. It has other characteristics of great value and originality, but these are only rendered possible by the peculiar shape in which the powder is moulded, and are, therefore, in a sense, subsidiary. . . . Whatever merit there may be in hyperbolic curves in a steam engine, there is none in a gun, for there the object aimed at is to impress the greatest possible amount of energy on the projectile with the least strain on the weapon. Evidently this can best be done by a pressure sustained uniformly from breech to muzzle, such as would be represented by a rectangular diagram. The maximum pressure and the average pressure then become identical, and for any given ballistic result the maximum pressure is greatly reduced below what it would be if there were sensible expansion of the gases in the bore.

"The result is sought to be attained in the Maxim-Schupphaus powder by giving to each grain such a configuration that the rate of burning shall keep pace with the motion of the projectile, and still maintain the space behind it filled with gases at a fairly constant pressure.

"If gunpowder grains be in the form of spheres or cubes, the rate of combustion is greatest at ignition, and gradually decreases as the grains diminish in size, while, on the other hand, the speed of the projectile through the bore rapidly increases. Hence the pressure of the gases is not maintained. The ideal condition is that each grain shall, at the moment of ignition, present sufficient surface to combustion to give the required pressure, and that this surface shall rapidly increase, so as to insure more and more vigorous combustion."

The Maxim-Schupphaus torpedo powder, that is to say, the grain I propose to employ for throwing high explosives from ordnance, is a cylinder, six diameters long, and pierced longitudinally with nineteen angular perforations. The perforations are so shaped and so arranged with respect to one another as to effect the complete consumption of the powder grain simultaneously with the intersection of the perforations with one another. In other words, when the perforations shall become so enlarged by interior combustion that they become tangent, the grain will be totally consumed.

The exterior of the grain is coated with a non combustible substance, which, although consumed before the projectile leaves the gun, and also with the absence of smoke, still serves to combine the combustion nearly wholly within the perforations.

The torpedo powder grain, as already stated, will only present one-fifth the initial area to the flame of ignition that is presented by cordite and about one-sixth of that presented by ballistite; consequently, under like conditions of confinement, there will be only one-fifth the initial pressure for the same charge, and possible variations in velocities and pressures can only be one-fifth as great.

Now, therefore, if we employ a projectile of twice the weight and with the same area of base as that now employed with cordite, with a pressure of 35,000 lb. to the square inch, we shall still have less than half the pressure and half the variations in pressures and velocities.

The key to a successful system of throwing high explosives from ordnance rests in the powder charge, or, rather, upon the character of the powder grain. The second in importance is the fuse; the third, the form of shell; and the fourth, the high explosive to be thrown.

It is popularly supposed that the most essential requisite to a successful system of throwing high explosives from ordnance is to get them out of the gun gently; that high explosives of all kinds are very ticklish, and have to be handled with the utmost caution, and that the chief thing to be considered in the projection of high explosives from ordnance is the danger of their premature explosion in the gun, due to the shock of acceleration.

But this is not the case. In fact, nothing could be farther from the truth than such conclusions, for there are many high explosives as powerful as No. 1 dynamite which may be handled and knocked about without any caution whatever, and which not only cannot be ignited when fire is applied to them, but which may be stirred up with a red hot poker without any danger, or be fired into with shells from quick-firing guns, without being exploded.

Such explosives may be thrown from ordnance at the same velocity with which ordinary shot and shell are now thrown from high power guns, and without the least danger from the shock of acceleration in the gun.

It is not generally known, but it is, nevertheless, a fact, that some of the most powerful of high explosives, such, for example, as wet guncotton, picric acid, known also under the names of lyddite, emmensite, and melinite, are already successfully thrown from high power guns at service velocities.

A compound of picric acid and nitro-naphthalin, together with an admixture of nitrate of ammonia, is one such explosive compound. Picric acid, pure and simple, however, is as powerful, volume for volume, as No. 1 dynamite, and it is, at the same time, wholly insensitive to any shock of acceleration to which it may be subjected in the gun.

Wet compressed guncotton may be fired from a gun at service velocities, and even exposed without any covering or protection whatever to the white hot gases of the propelling charge, a portion only of the wet guncotton being burned under the high heat of the powder gases.

An aerial torpedo filled with wet compressed guncotton would not be detonated by a quick-firing gun shell loaded with black gunpowder penetrating it and exploding within the mass of wet guncotton.

Now, as it is the length of column of explosive in a shell which endangers it from the shock of setback or acceleration, we may increase the size of the projectile in cross-section indefinitely, to provide greater space for explosive, without adding in the least to danger from shock in the gun.

(To be continued.)

It is expected that during the present year the number of "Gebrauchsmuster" granted by the German government will equal the number of patents, viz., 100,000. This is the more remarkable since the Gebrauchsmuster law has been in force for seven years only, while patents have been granted since 1877.—Uhland's Wochenschrift.

A NEW ROTARY STEAM ENGINE.

UP to the present, rotary motors in which the admission and escape of the steam take place, in determinate cases, under the influence of the circular motion, have presented great difficulties in the way of construction and have not given all the results that they seemed to promise. Messrs. Arbel and Tihon have recently devised a new motor of this kind which they designate by the formula of the circle πR^3 (in order to recall its really rotary character), and the novel principle of which it appears to us of interest to make known.

The apparatus (Figs. 1, 2, and 3) consists especially of a double jacketed cylinder, *C*, in the interior of which rolls a piston ring, *G*, carrying at its upper part a partition, *H*, always connected with a special oscillating piece, *II*, and contributing toward continually dividing the interior space into two compartments, the capacity of one of which varies in inverse proportion of that of the other. Two cocks, *JJ*, placed on each side of *II*, serve to establish the admission escapement according to the direction of running it; and the maneuvering is very easily effected by means of a simple handle that actuates a toothed wheel that gears with the two cocks. The motion of the piston ring is transmitted to the driving shaft, *D*, through the intermedium of two symmetrical cams, *EE*, united at their center by a rod and nut, *F*, which permits of regulating their distance apart. The joint between these two cams, placed in the axis of the motor, therefore constitutes a more or less open channel in which is placed a series of tempered steel balls, that roll upon a corresponding path arranged in the interior of the piston ring. Two cheeks traversed by the driving shaft close the cylinder at the sides; and a perfect tightness between these cheeks and the lateral faces of the piston ring is obtained in a very original way, thanks to the property that cork possesses of swelling under the influence of humidity and steam. The sections in Figs. 2 and 3 show how the apparatus operates.

At the last Exposition of Automobile Carriages, the inventors operated in public a πR^3 motor, which attracted much attention. It was of 6 h. p., weighed 308 pounds, made 300 revolutions a minute and occupied a space of but 14 × 12× 24 inches.

The inventors propose to apply this motor to the propulsion of heavy weight automobile vehicles and of boats.—Le Genie Civil.

FIG. 1.

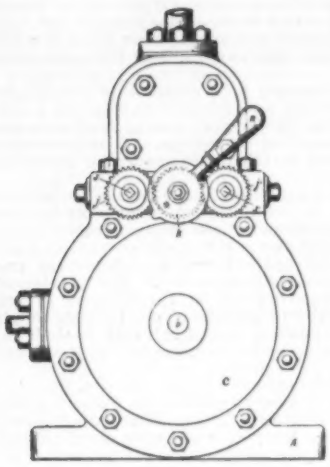


FIG. 2.

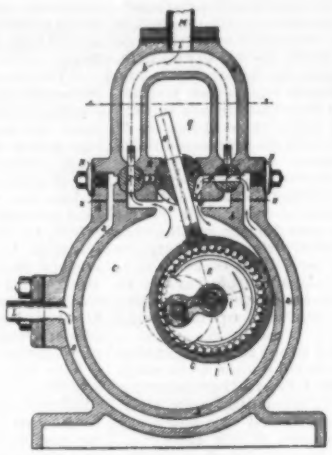
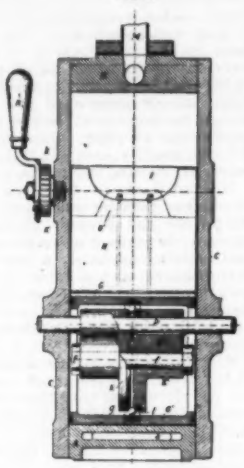


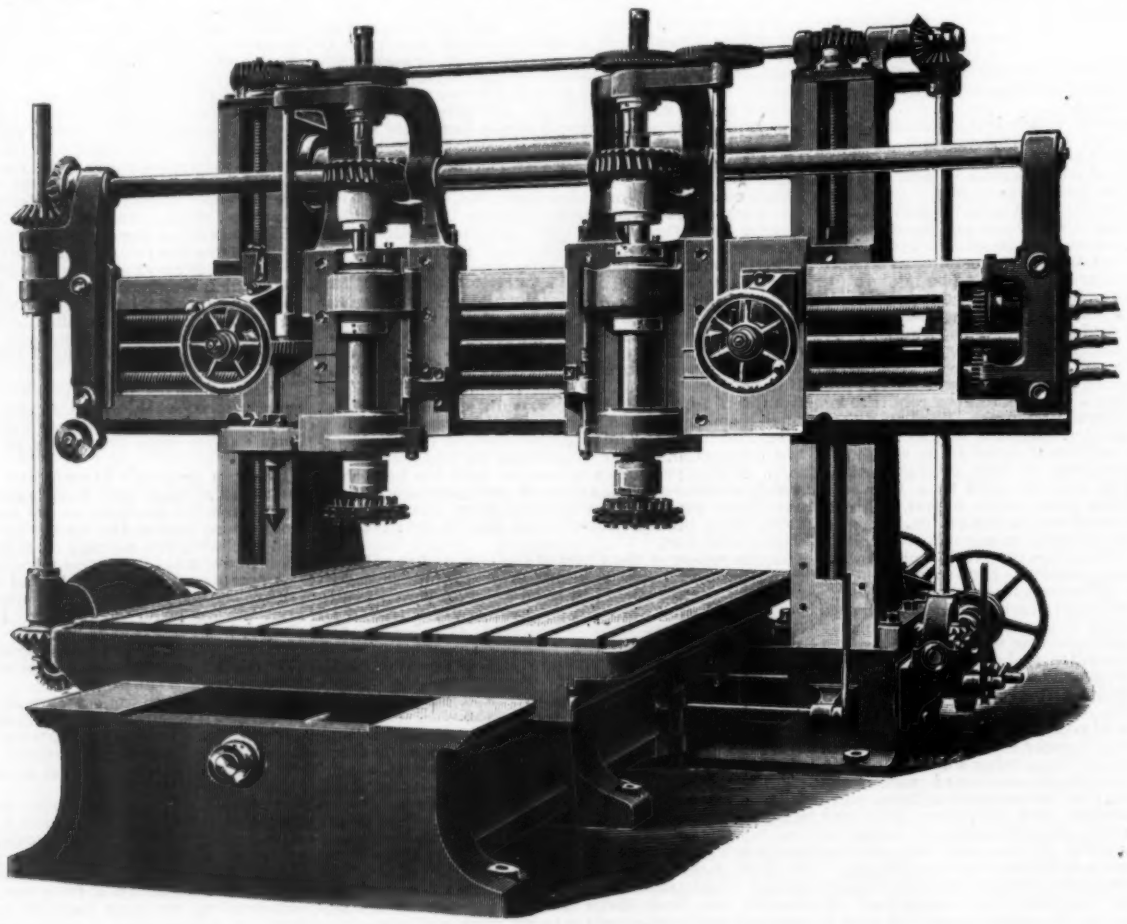
FIG. 3.



NEW ROTARY STEAM ENGINE.

TWO-SPINDLE VERTICAL MILLING MACHINE.

WE illustrate a very powerful two-spindle vertical milling machine, constructed by Messrs. Hulse & Company, of the Ordsal Works, Salford, Manchester. The machine is of the planing machine type, and will admit work 6 feet wide between the uprights, the cross-slide having a vertical adjustment on the uprights of 2 feet. The feed motion is imparted to the table through a swing frame and change wheels, and is consequently both positive and capable of great variation to suit the variety of work which the machine will deal with. The table has also quick power traverse motions in either direction, the levers for applying and suspending these and also the self-acting feed motions being within reach of the attendant in his working position. One of the two cutter head stocks is arranged for profiling work, each having variable self-acting feed motions along the cross-slide, and carrying a vertical slide fitted with a strong steel spindle running in conical bearings and provided with every adjustment for taking up wear. The spindle noses are fitted with patent chucks for readily gripping and withdrawing the cutter arbors without any driving in and out of cottars. To insure perfect immunity from breakdown in inaccessible parts, the gearing underneath the table and within the bed is made of cast steel.—Engineering.



TWO-SPINDLE VERTICAL MILLING MACHINE.

NOTES ON REPAIRS TO GAS AND OIL ENGINES.*

THE theory and developments of internal combustion engines have repeatedly furnished subjects for discussion in technical journals of the day, but in almost every case they have appealed to the inventor and designer rather than to the man who is called upon to repair or attend to these motors. So large is the number now manufactured that a jobbing shop can hardly fail to have its share of them to keep in order; and as mechanics in such shops are called upon to do repairs to almost every variety of machine, some account of the practical requirements of these engines, necessary to insure their satisfactory working, may not be out of place.

One of the special features of these engines is the almost trivial cause which will prevent their running. With a steam engine, provided steam is turned on and the valves are something near the mark, the working of the engine can be relied on; and even if it will not work, the cause can usually be located instantly. But with gas or oil engines it is very different, and often those with wide experience of them find it very difficult to say where the fault lies until every working part has been examined.

The majority of engines, whether oil or gas, as now made, work on what is known as the "Otto cycle," the analysis of which is as follows:

1. Outstroke of piston, sucking in gas and air.
2. Instroke, compressing same.
3. Outstroke (working stroke), due to explosion and expansion of charge.
4. Instroke, expelling the burned gases.

The knowledge of this cycle of operations at once clears up any mystery as to the setting of the valves. It will be seen that only one working stroke occurs out of four, or in two revolutions, and for this reason the valves are usually worked from a small second motion shaft geared to run at half the speed of the crank shaft or else some device is used to operate the exhaust valve every second revolution, and the inlets work by suction only.

The first care, if an engine refuses to start, is to see that the valves are all working at their correct times, for it is not unusual to find, if the engine has been in incompetent hands, that the countershaft has been removed and replaced in the wrong gear relative to the main shaft, with the result that all the valves are astray; or the timing arrangement on the firing valve (supposing one is on the engine) may have been set to work so late that the charge is not fired at all. The order in which the valves open and close is as follows, using the same numbers as above:

1. Air and gas valves open at or soon after commencement of stroke, and close just before the end.
2. Air valves close.
3. Firing valve (if fixed on engine) opens slightly before, at, or slightly after commencement of stroke. Exhaust valve opens at about nine-tenths of this stroke.
4. Exhaust valve open throughout stroke.

If the valves are all correctly set, and the source of trouble is not there, the firing tube should be examined, to see that it is sufficiently hot (a dull red is not enough); or if the tube is suspected of being furred up

* Contributed to the Mechanical World.

inside, it should be removed and examined, and if in any way gone, be replaced by a new one. The engine should also be tried round slowly on the compression stroke, to make sure that no joint or valve is leaking, as any loss there means waste of power and liability to misfire. The certainty of ignition, particularly with engines having no firing valve, depends upon the charge being compressed up into the tube high enough to reach the hot part of it, so that with a loss of compression failure to explode will follow. If there is leakage, the valves will probably be found to be dirty, or so burned as to require regrinding on their seatings. Dirt is very frequently the cause of trouble with oil engines, in which there is often a deposit of a greasy soot, capable of hardening like cement after finding its way into every internal working part. The piston rings under such conditions soon give out and almost have to be chipped out of their grooves to remove them. When this is the case, there is certain to be a leakage at the rings, as there is no longer sufficient elasticity to keep them tight.

With oil engines using paraffine or other heavy oils, the exhaust should be watched, as smoke indicates imperfect combustion and the certainty of the above mentioned soot being deposited, as well as unnecessary waste of oil. Under such circumstances the quantity of oil consumed will be found to be considerably in excess of the pint or three-quarters pint per brake horse power usually advertised by makers. Cases can often be found in which the engine is so carelessly attended to that not only are clouds of smoke ejected from the engine, but even a spray of hot oil as well. As a remedy the vaporizer should be examined and maintained at a sufficiently high temperature, and the supply of oil to it most carefully regulated, as the small quantity required per working stroke, if ever so slightly exceeded, will be found to make a very perceptible difference in the total amount used at the end of a day's running. Where the vaporizer is kept hot by the explosions in the cylinder, its temperature may fall too low to work efficiently from either misfires or light running with the governor cutting out. This latter cause is in many engines guarded against by having the governor to act upon the exhaust valve, by keeping it open, so that the hot water gases are again drawn into the cylinder. The inlet valves, which in such a case are operated by suction only, do not open, and thus no cold air enters the cylinder or cools the vaporizer. If such a type of vaporizer has become too cold, it must be reheated by the means provided on the engine.

In engines having a very large clearance space a quantity of burned gases always remains in the cylinder, and with badly arranged valves or with the ignition tube in the wrong place may be the cause of misfires. To get rid of as much as possible of this incombustible residue, various devices are used, two of the most notable being as follows: After the discharge of the exhaust gases, a charge of air only is drawn in and expelled before taking in the next charge, the method being known as scavenger charge. As that reduces the working stroke from one in two revolutions to one in three, it is not very commonly used. The second method is to keep open the exhaust valve until the following suction stroke has well begun, the object being to employ the momentum acquired by the exhaust gases during the back stroke for the purpose of drawing out more. The fitter should, therefore, not be misled into the idea that such a valve is wrongly set. It is then the position opening, rather than that of closing, to which he should give his attention.

The foregoing suggestions will, in nine cases out of ten, be found to account for the failures to work in this class of motor; and as they deal with the conditions under which working is possible, they will be found to apply to practically every type of gas or oil engine.

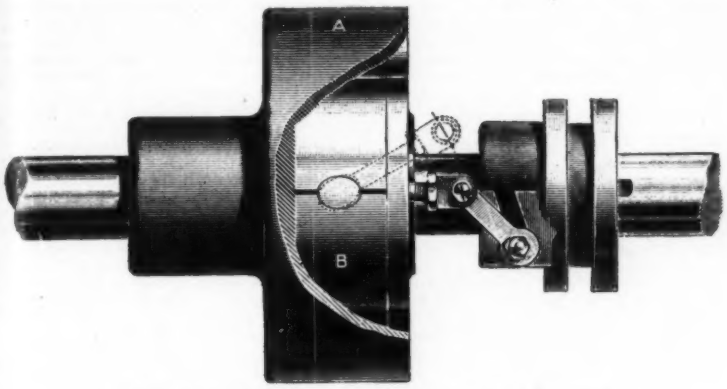


FIG. 1.—BROOKE'S FRICTION CLUTCH—PLAN.

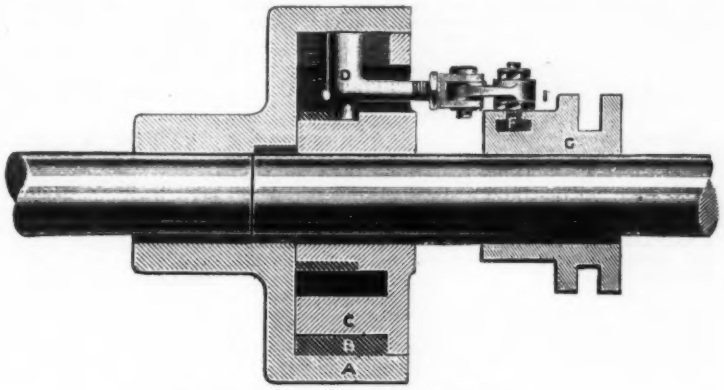


FIG. 2.—SECTIONAL ELEVATION.

FRICTION CLUTCHES.

WE illustrate herewith a friction clutch manufactured by Messrs. J. W. Brooke & Company, Lowestoft. The illustrations, for which we are indebted to Machinery, show the clutch applied as a shaft coupling. By means of the reference letters we can readily explain the details of the clutch. *A* is an external cast iron or steel friction shell. *B* a steel expanding friction ring, which can—in the event of wearing—be renewed. *C* a casting, consisting of a central boss, with plate and flange, which is embraced by the friction ring, *B*. This casting also serves for a dust proof cover to the shell, *A*. *D* is the friction ring expander, which is made of steel and hardened. The part which fits into the steel shell, *B*, is of such a shape that when it receives a partial rotary movement it expands the ring, *B*, against the inner surface of the shell, *A*, binding the whole firmly together, thereby driving a pulley or wheel, as the case may be. *E* is a short link connecting the expander, *D*, to the sliding sleeve, *G*. On pressing the sleeve, *G*, into the driving position or toward the clutch face, the link, *E*, will be brought parallel with the clutch face, or at right angles to the shaft, and remains in this position without any end pressure when driving. The wear on the friction ring is taken up by the tee bolt, *F*, in the slot. When the clutch is not in gear, a simple contrivance keeps the ring, *B*, closed, so that it does not come in contact with the shell, *A*. With some classes of high speed machinery, and also for haulage work, it is necessary to have a considerable amount of slip before starting; to provide for this extra wear, an inner lining of cast steel is secured in the shell, *A*, which can be renewed at a trifling cost.

Fig. 3 shows the Brooke universal clutch applied to a cast iron pulley, which is self-explanatory. We may point out one great advantage of the clutch under notice; by means of the elliptical expander a high degree of frictional contact is obtained with little or no leverage on the sleeve; it can even be operated by hand. Fig. 4 shows a self-sustaining clutch barrel hoist, designed for lifting sacks and loads up to 5 cwt. at a small cost. The construction is extremely simple, and it is almost impossible for the device to get out of order. It is placed direct on the shafting, so that no belting is required, and it is manipulated by one lever. It is under complete control, and can be worked by a lad. The barrel is fitted with the Brooke clutch, differing from the ordinary and expensive friction hoist, which is subject to great wear; this hoist being a positive mechanical action sustains the load at will.

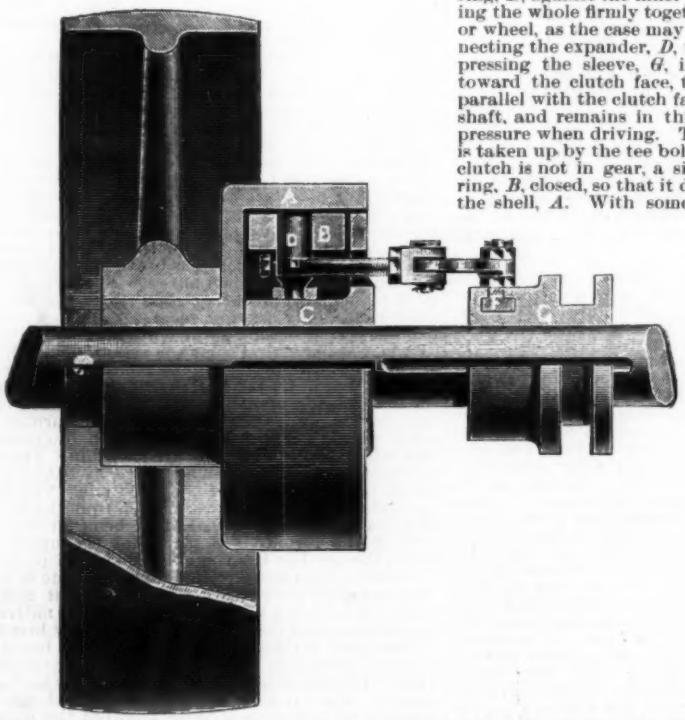


FIG. 3.—FRICTION CLUTCH AND PULLEY, BY MESSRS. BROOKE & COMPANY.

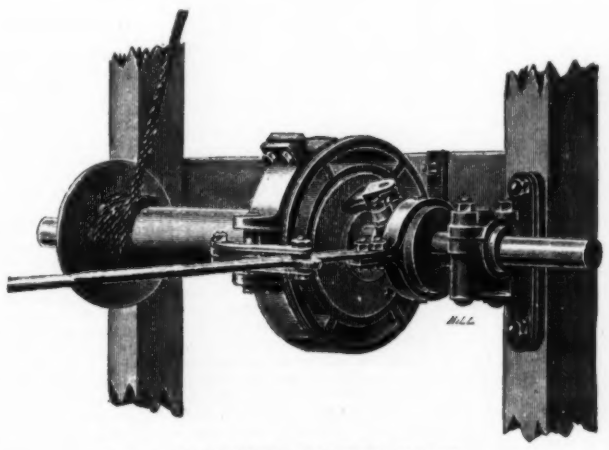


FIG. 4.—BROOKE'S BARREL HOIST.

SAND BLAST FOR CLEANING WALLS.

THE sand blast has been applied to the work of cleaning the stone walls of Pardee Hall, Lafayette College. The interior of the building was destroyed by fire some time ago, and after the standing walls had been pronounced safe for rebuilding, this method of removing the smoke stains and crumbled surface was selected. The compressor was one of Ingersoll-Sergeant's direct-acting type, having a 10 × 10 inch steam cylinder and a 10 × 14½ air cylinder. Ward & Nash sand blast apparatus was used. From the air receiver the air was carried by a pipe to the third floor of the building, and from thence by a hose to the portable sand blast apparatus. The velocity given to the sand is said to have been quite high, and the bombardment of the particles cut away the discolored surface in a very rapid and satisfactory manner. The pointing between the stones was cut away, but that had nearly all been cracked by the fire and would have had to be done over again anyhow. The sandstone arches and facing around the windows was cut away very rapidly, and care had to be taken that the dressed edges were not spoiled.

UTILIZATION OF INDIAN CORN STALKS IN RUSSIA.

ON the 19th of July, a most interesting experiment was made by the Russian Admiralty at the naval proving grounds at Poligon, near St. Petersburg.

A coffer dam 6 feet long, 6 feet deep, and 3 feet broad was packed with blocks of cellulose made from the pith of Indian corn stalks. The material was supplied by the Marsden Company, of Philadelphia, and the dam was packed under the supervision of the experts of that company. The cellulose within the dam was compressed until it weighed 8 pounds for each cubic foot. A 6-inch solid shot was fired through the dam, striking it a distance of about 20 inches from the bottom. The shot struck the dam at a velocity of 1,000 feet a second and passed clear through both the iron walls and the cellulose packing. Less than half a pound of the cellulose was carried out by the projectile. The water compartment of the dam was filled, giving a pressure of nearly 5 feet of water on the perforated surface. In just half an hour a moist spot began to show on the outer surface of the dam, but it was evident that the moisture had come along the bottom of the packing and not through the path of the shot. In four hours no water had come through the shot's path, and only 6 gallons had passed under the packing. The experiment conclusively demonstrated that a ship provided with a coffer dam packed as was the one used in the experiment could be perforated 5 feet below the water line without the least danger of the entrance of water. This demonstration opens up an immense market for Indian corn pith, and will prove of great advantage to American agriculture.

Among those who were present at the trial were Admiral Decker, director, and Colonel Ricosanin,

deputy director, of the naval proving grounds at Poligon; Colonel Nicolas Zitoff, member of the naval construction board of the Russian navy; Mr. Henry C. Watts, representative of the Marsden Company; Mr. Irving Scott, president of the Union Iron Works, of San Francisco; Dr. H. W. Wiley, representative of the Department of Agriculture, Washington, D. C.; and many others.

After extracting the cellulose for packing coffer dams and other purposes, the outer envelope of the stalks is ground into an excellent cattle food. This property of the maize stalk is of the greatest importance. It is evident that this waste product of the vast maize fields of America is destined to interest European nations and find eventually a wide market.

Similar trials of maize pith as an obturating material for battleships have been made in England with favorable results. W. R. HOLLOWAY, Consul General.

St. Petersburg, July 25, 1898.

THE VALUE OF PHOTOGRAPHIC RESIDUES.*

FROM correspondence, as well as from communications to home and foreign professional papers, I continue to hear complaints concerning the small sums paid to photographers for their silver residues. About a month ago a Hungarian photographer wrote to me that he had received only fl. 25 (2l. 1s. 8d.) for three and a half kilos of silver chloride and eight kilos of paper ash, although these residues may have been worth fl. 100 (8l. 6s. 8d.)

In my Guide to the Rational Collection of Silver, Gold and Platinum Photographic Residues and the Determination of their Value there is a complete account of all the best methods of recovering the precious metals from photographic baths and washing waters. On page 2 there is a table of the theoretical and actual amount of silver contained in chloride of silver residues, likewise of the actual amount of silver contained in the trimmings of various kinds of silver paper. The following remarks will render these more complete:

A kilogramme of dry, pure chloride of silver contains 750 grammes of metallic silver, which at the market price of silver at the time of the publication of my book was worth fl. 37 to fl. 38 (3l. 1s. 8d. to 3l. 3s. 4d). † In practice, it has been found that chloride of silver residues, sent by photographers to the refiners, never contain this amount of metallic silver. In the following eight samples of silver residues I have calculated the actual amount of silver present per kilo:

1. 645 grammes	Ag.	5. 453 grammes	Ag.
2. 687 "	"	6. 541 "	"
3. 475 "	"	7. 673 "	"
4. 628 "	"	8. 627 "	"

The average amount of silver in these eight samples is 600 grammes, being equal to fl. 28 per kilogramme of chloride residue. But there is no reason why the photographer's residues should not be of the richest kind, if they are collected rationally. In the examples given, the largest amount of silver per kilogramme was 687 grammes, which was worth fl. 32 (2l. 13s. 4d.) According to this, the three and a half kilogrammes of chloride residues, to which we have referred, should be worth fl. 112 (9l. 6s. 8d.) if carefully collected and dried.

For precipitation of the silver chloride, hydrochloric acid is preferable to common salt. Paper coated with emulsion, if washed in hard water, often gives an extraordinary amount of calcium salts, which is again soluble in hydrochloric acid. Silver is usually precipitated as sulphide from fixing baths by means of liver of sulphur. Herr Weiss received fl. 26·45 (2l. 4s.) for a kilogramme of silver sulphide obtained in this way. This return compares less favorably, because there is usually a large amount of sulphur mixed with the silver sulphide, and therefore the value of the silver obtained from Ag_2S is less than from silver chloride. Nevertheless, the sum of fl. 26 per kilo for sulphide residues is well worth attention, and the various fixing baths should never be thrown away, which unfortunately is too often the case even in large establishments. Some employe or assistant in the business would, doubtless, be very glad to look after the waste, if some portion of the returns were given him for the trouble. We should mention here that sulphide of lead is also precipitated where combined toning and fixing baths are used; consequently, the entire residue would contain, besides sulphide of silver, sulphide of lead, sulphur, a little sulphide of gold, and oxide of aluminum. Those photographers to whom the smell of sulphureted hydrogen is objectionable I would recommend to use zinc dust for precipitating silver from the fixing baths.

The proportion of silver contained in the ash from silver paper varies very considerably. From practical experience the amount varies from 30 to 600 grammes per kilo, or in money from fl. 1·70 to fl. 27 per kilo (2s. 10d. to 2l. 5s.) From this it is evident that the value of the ash depends upon the source of supply. It may also be of interest to the professional photographer to know the value of the trimmings from collodio-chloride paper. As no particulars are to hand for reference, I have ascertained the amount of silver in a weighed quantity of unfixed collodio-chloride paper trimmings, and have found that one kilogramme gives 211 grammes of ash, which latter contains 56 grammes of silver. Consequently, one kilogramme of collodio-chloride trimmings is worth 1 krone (10s.), and 1 kilogramme of ash 5 kronen (2l. 10s.)

It should also be remembered that a considerable amount of silver may be lost in burning the paper without proper appliances. It would therefore appear preferable to send the paper direct to the refiners, or to fix out the silver in old fixing baths. The silver can be easily recovered from old fixing baths.

The professional photographer is not so much at the mercy of the refiner as is usually supposed, and should observe certain rules, which I would summarize as follows:

1. The residues should be collected in the purest form, and should be free from foreign substances, such as corks, etc.

2. The residues should be well dried by exposure to air before storage.

3. Chloride, sulphide, metallic silver, etc., should each be kept separate and stored apart.

4. Reliable average samples should be taken of each kind of residue and kept in bottles. Samples should be sent to the refiners for determination of the quantity of fine silver contained. The cost of these tests is small.

5. Before sending the residues to the refiner they should be weighed. The total value may then be ascertained from the sample tests. (Rule 4.)

The complaints to which we have referred may not cease if these rules are observed, but the latter will be of service to the professional photographer and to well known reliable refiners. The publication of exact returns and of further particulars will bring about more regular conditions in the valuation of residues.

We would mention, in conclusion, that it is desirable to divide the residues in equal parts and send them to different refineries. Considerable difference will be found in the amount returned from each, notwithstanding the equality in value of the parcels sent.—Prof. Alexander Lainer.

* Translated from the Photographische Correspondenz and printed in the British Journal of Photography.

† One kilogramme of silver could then be sold for fl. 47 (3l. 18s. 4d.), or bought for fl. 50 (4l. 3s. 4d.)

CUTTING WASTE NEGATIVES FOR COVER GLASS.

By R. P. C., in The Amateur Photographer.

MY method of cutting negatives for lantern slide cover glasses until recently has been as follows: Having a good stock of waste quarter plate negatives which have been previously cleansed, also a glass cutter and straight edge, I lay about a dozen glasses in a row, side by side, on the table, close up together, the 3¼ inch side being tight against the straight edge. I place one glass on each end of row, the 4 inch side against straight edge. Remove the straight edge and place it on the glasses, using the two end glasses as a gage, when they can be cut off quite easily. Of course you must allow for the thickness of the cutter, which will be about one-eighth of an inch. But finding that my glasses when cut varied a trifle in size, I made a wooden gage for cutting, which answers first class and was made in about fifteen minutes. Having a piece of 1 inch board 7 inches square and a piece of picture frame backboard 2 feet long, 1¾ inches wide, with a straight edge on one side, I cut two lengths off same 7 inches long and two 5 inches long. I tacked one 7 inch piece on the board, with the edges flush, the straight edge being on the inside, and treated one of the other sides similarly, only using one of the 5 inch pieces, the two inside edges forming a square (a negative glass answering the purpose of a square), the other 5 inch piece was tacked on the opposite side, and the remaining 7 inch piece across the top,

3⅛ inches from the back piece, which allows for the thickness of cutter. By cutting a half round piece out of the front of board the glasses can be drawn out quite easily, half sprigs being used for putting together. By having it made wider it could be used for cutting half plate glasses. Rough sketch will make my explanation more clear.

PREHISTORIC WEAVING IN ENGLAND.

VERY little reliable knowledge has come down to modern times regarding the textile arts of ancient Britain. There is every reason, however, to believe that these arts were as advanced in England as in the neighboring countries of the Continent. The perishable nature of textile material in a damp climate is undoubtedly the reason why so few vestiges have escaped the destructive influences of time, and why these have rarely been preserved after discovery. They have mainly consisted of the cerements of distinguished individuals, found by our modern Vandals, whose curiosity leads them to desecrate their tombs. The famous Boadicea, Queen of the Iceni, whose realm included the area around our present metropolis, in, we believe, the last of her encounters with the Roman forces was stated to have been dressed in a checked costume of white and blue. This would undoubtedly be a linen fabric, with a mingled white and woad-blue warp, crossed by weft of the same hues and material. The manufacturer of such a fabric implies a fair degree of knowledge of the textile arts. Very likely woven fabrics would be almost the exclusive use of the chief men of the different tribes, the common people dressing in skins, or going to a great extent naked, especially in the warm season. The Romans introduced their methods of weaving soon after their advent, and a woolen manufacturing mill or establishment was founded at Winchester. But whatever progress may have been made under their tuition, it was probably destroyed after the retirement of the Romans and upon the advent of the Angles, Jutes, and Saxons, who slaughtered or drove the natives before them into the fastnesses of the hill districts, and destroyed whatever was left behind. It is very probable that the paucity of remains of the textile arts of the ancient people is due to the ancestors of the nation of to-day.

We are led to these reflections by the communication of a correspondent of The Times, who writes that: "The site of the prehistoric Celtic lake village, near Glastonbury, has been further excavated since July last under the superintendence of the discoverer, Mr. Arthur Bulleid. The sites of the dwellings are marked by mounds. One of these contained the greatest depth of clay yet found, no less than 9 feet; the accumulation of successive hearths which were found necessary as the weight of the clay gradually compressed the peat beneath. This mound contained 300 tons of clay, all of which must have been brought in their boats by the inhabitants from the neighboring hills. Under the mound was found the framework of a loom with brushwood and wattlework to form the foundation. That the inhabitants were much engaged in spinning is clear from the fact that, in addition to other things connected with the craft, no fewer than forty horn and bone carding combs have been unearthed. Strangely enough, no two of these are of exactly the same pattern. As in previous seasons, a large number of bone articles have been discovered. The number of broken bone needles and splinters of bone found in one mound seems to indicate that it was utilized as a needle factory. Another mound was very rich in fragments of pottery and other evidences of the manufacture of hardware. No fewer than ten bronze fibulæ were found, these being fashioned almost exactly like the modern safety pin. Two bronze studs, probably a part of harness or for fastening clothing, were also found, together with other small bronze articles. A neatly cut iron file about 8 inches long was found. As usual, very few human remains were discovered, part of the skeleton of a very young child being all that was brought to light this summer. With the exception of the cracked skulls of a few unfortunate warriors, the remains of young children have chiefly been found in past years, Mr. Bulleid being of the opinion that these primitive people conveyed their dead to the neighboring hills for interment." This unearthing of a prehistoric loom is very interesting, as it draws aside, though in an imperfect manner, the veil by which Time has hidden these things of the past from our knowledge.—Textile Mercury.

THE MINES OF ETHIOPIA.

NEAR Okfeltch, two days' march from Vitche in a northeasterly direction, there is a coal mine, and the very apparent crop-out extends for about twenty yards; the place itself is called Elliassaguer. Nobody, however, shows the slightest desire to work it, and the natives use wood for fuel, particularly that of the olive tree, which is very abundant in their forests. Neither do they exhibit the least inclination to properly exploit the gold mines existing in the Gallas provinces. They treat the latter with nearly the same contempt as the former, and the precious metal is taken in its raw state to the markets on the Egyptian coast. Salt, on the contrary, plays a very important part in the commerce in those regions, for it is both scarce and much needed, and serves throughout all Ethiopia as money, the only metal coin used in the country being the talari. This is a silver thaler coined at Trieste, and bearing the effigy of Marie Therese of Austria; it is equivalent to 4s. 8d. The salt imported to the Gallas provinces comes from a mountain of rock salt in northern Ethiopia, on the road from Massouah to Tigre. It is retailed in the form of very hard blocks, about 8 inches in length and 1½ inches in width and thickness; they are a little thinned toward each end, and have almost the exact shape and size of a scythe whetstone. Their value varies according to the district, from eight to twelve for one talari. At Finfani, in the same region, at a day's journey from the river Aouach, there is a high horseshoe shaped mountain which dominates the Berbecha country.

Finfani is in reality the name of the warm mineral waters, and it is there that the iron mines which we will now examine are found. The tools employed for the exploitation are very rough and primitive, and the mines are open like a quarry. At first sight they appear to be very rich, but their actual wealth is still unknown. The native ironfounders proceed in the following manner: They have a clay blast furnace in the form of a funnel, and of a capacity from nearly nine to eleven gallons; four buckskin bellows, manipulated by two men, communicate with the lower part. When the furnace is well alight the funnel is filled with the ore, which has previously been broken into small pieces, and then mixed with charcoal; a metallic plate sealed with clay then closes the mouth of the furnace, only leaving room for the action of the bellows. This method approaches indeed very closely to the Catalonian. Under the action of the fire the ore becomes soft, and with the charcoal forms a kind of paste, but never reaches the liquid state, owing to the insufficiency of the caloric. The produce of this imperfect fusion is then taken from the furnace, and, when cooled, it is once more broken in fragments before being submitted to the furnace again. The workmen measure the ore by small heaps, as bakers do the dough to obtain loaves of the same size. The second operation does not differ very much from the first, except that the bellows, instead of being at the lower part of the furnace, are placed at the upper part. When the ore has been again reduced to paste, it is withdrawn with tongs. This time the paste is beaten on a large flat stone, very slightly at first and then heavily, and then a kind of dross which the natives call the excrement of the iron exudes and easily breaks off.

The metal is then given the shape of a broad thin cake, weighing from 16 pounds to 19 pounds avoirdupois. The iron obtained in this primitive manner is of a very superior quality, and the waste is almost nil. The working of the mines is quite free, but the only fuel employed in the furnaces and in the country generally being wood, and that not being used economically, the clearing of the forests is progressing very quickly. Already a whole forest of gigantic olive trees has completely disappeared in the neighborhood of Finfani. It is evident that some day, perhaps not very far from the present time, the result will be a lack of metal owing to the want of fuel. The quantity of metal, however, extracted from these mines in such a rudimentary way is still very considerable. Bits for horses and mules, stirrups, gun barrels, plowshares, swords, and tools of all kinds are manufactured from the iron of Finfani; the Ethiopian industry, in fact, does not know another.—Engineer.

France's Imprimerie Nationale is preparing as a show piece for the exhibition of 1900 "The History of French Printing in the Fifteenth and Sixteenth Centuries," by A. Claudin, with 1,200 plates of reproductions from rare books.

ENGINEERING NOTES.

A railway accident near Genoa, Italy, in which 9 persons were killed and 40 seriously injured, is reported to have occurred on August 11. A heavy freight train drawn by three engines became stalled on a steep grade in the Glori Tunnel. The tunnel soon filled with gases from the engines, which asphyxiated the engine drivers and firemen, leaving the train to run backward and crash into a passenger train standing at the entrance of the tunnel.

That shells charged with high explosives are not so dangerous to handle as has been generally supposed has been proved by an accident on board the French second-class cruiser "Catinat." In this case a number of 3·9-inch shells charged with melinite were being placed on board, when half a dozen of them were allowed to drop into the hold. Wonderful to relate, no explosion followed, a result which can only be regarded as most providential, as its consequences would have been most disastrous.

The Matin publishes an interview with M. Lockroy, Minister of Marine. M. Lockroy stated that the naval programme which he intended to carry out comprised the extension of mobile defenses, the construction of guardships, of torpedo boats, and automobile mines, the building of large and fast ironclads of the "Dupuy de Lome" type, besides the completion of ironclads now on the slips, the repair and fitting out of all the vessels composing the present fleet, and the establishment on all the routes leading to the French colonies of numerous coaling stations, where warships could obtain provisions and coals, and also find a safe shelter.

At the coming exposition in Paris, no less than 15,000 horse power will be used for lighting and 5,000 horse power for furnishing electric power to the various parts of the grounds. As far as possible all the machinery exhibited will be shown at work, and for this purpose electric conductors will be laid down to all points on the grounds. The boiler plant will be located at the end of the Champ de Mars, and will occupy two spaces of 130 by 390 feet each, one being for French boilers and the other for those of foreign makers. This plant will be in itself a very interesting exhibit. It is proposed to provide a capacity for evaporating not less than 440,000 pounds of water per hour.

A pile-driving record is reported from Manitowoc, Wis., where Mathews & Keith, contractors of that city, are building a grain elevator for the Northern Grain Company, of Chicago, says Engineering News. On June 22, pile driver No. 5 drove 151 piles in 10 hours and pile driver No. 4 drove 140 piles in the same time. These piles were from 20 to 24 feet long, and they were driven from 18 to 20 feet into the ground to a hardpan stratum. The pile drivers were specially designed by the above firm, and have a 5,000 lb. hammer, operated by 30 inch double drums and a 30 horse power engine. Similar drivers were used at Buffalo, N. Y., in putting in the foundations for the Great Northern steel grain elevator.

The new Vickers 6-inch wire-wound rapid-fire gun, officially tested some time ago at Portsmouth, England, is 45 calibers long and weighs 7 tons 8 cwt. The breech mechanism is lighter and stronger than in older types, and a single motion of a horizontal lever opens and closes it. In the trial this gun developed a muzzle velocity of 2,780 foot seconds and a pressure of 15·9 tons per square inch on the breech. The striking energy of the projectile was 5,374 foot tons as compared with 3,556 foot tons in the ordinary 6-inch gun. Aiming at a target 3,000 yards away, the rate of firing was one round in 10 seconds; and unaimed shots were fired at the rate of one in 9¼ seconds. In all, 110 rounds were fired without any damage to the gun or its mount. In a second trial, after 200 rounds had been fired, the gun showed no decrease of accuracy; in the test for rapidity of fire 36 rounds were fired in 4 minutes 47 seconds, and the maximum was one round in 6½ seconds and one set of eight rounds in 7 seconds each.

Cable-worked tramways in this country are few and far between. Hence the name of their inventor—Mr. A. S. Hallidie—is hardly known except to tramway engineers, and by many of them it has possibly been forgotten. However, it is well and worthily remembered in San Francisco, and on the 1st of August it was just twenty-five years since the first cable passenger railway car in the world began operations in that city. It has been suggested that a record of the creation of this invention be made be erecting a cast steel pillar in a prominent position in the city. At a meeting of the local mechanics' institute it was resolved that, "The institute, through its board of trustees, does hereby testify to the value and importance of the invention of the street cable railway, and recognizes the genius and worth of Mr. Hallidie, whose patience, perseverance, and energy enabled him to overcome the difficulties and discouragements encountered in its construction and introduction."

Attention has several times, in the columns of Engineering, been drawn to the rapid and continuous development of the river and canal traffic in Germany. Another important addition has quite recently been made to the numerous works undertaken for the advancement of the German water traffic by the opening of the large new harbor at Cologne. The ancient fortifications proved for a long time a serious obstacle to any material extension of the harbor accommodation, and it was not till the former had vanished that the contemplated extension could be taken in hand in earnest. The bank of the Rhine has been regulated and turned to account for a distance of over seven miles. The crane installation is very comprehensive, there being altogether fifty-one cranes. The various buildings are very handsome, and the total expenditure amounts to some $7,500,000. These installations are all on the left side of the Rhine, and are intended for various kinds of merchandise; while the more bulky commodities, such as timber and coal, will be provided for on the opposite side, where also petroleum tanks will be constructed. The new harbor and quay arrangements at Cologne are the best on the Rhine, and will, no doubt, tend to give a great impetus to the trade and industry of this ancient city.—Engineering.

MISCELLANEOUS NOTES.

The cement industry of Japan is said to be growing very rapidly. In 1897 the native factories turned out 600,000 barrels of 400 pounds each of Portland cement and 10,000 barrels of natural hydraulic cement. The Portland cement was valued at four silver yen, or about $2 per barrel.

According to the Pharmaceutical Journal, a fresh use for seaweed is claimed to have been discovered by a Norwegian engineer, who exhibited an invention at the Stockholm Exhibition for producing paper glue, dressing gum, and soap from seaweed. The first establishment for this branch of manufacture was, according to his statement, to be erected in the district of Stavanger, but, up to the present, nothing appears to have been done in this direction.

Elisee Reclus, geographer and anarchist, has been pleading before the Royal Geographical Society for the construction of a revolving globe on the scale of 1 in 500,000, or eight miles to the inch, which would make it possible to represent every marked elevation or depression on the earth's surface. The diameter of the globe would be eighty-four feet. His project is a modification of the plan he proposed for the Paris Exhibition of 1900, for which he could not obtain the needed money in France.

Native instinct in India—and elsewhere for that matter—sometimes accomplishes what technical training fails to manage. Sir James Westland recently told a United Service Institution audience that in the second Burmese war the British managed to upset the big Burmese bell, weighing forty-odd tons, into the Irrawaddy, in endeavoring to ship it off to Calcutta as a trophy. The engineers of the force tried in vain to raise it, eventually giving up the task as impracticable, when some Burmans asked to be allowed to try, and successfully accomplished it bv the simple expedient of timbering up the tapering end of the bell so as to convert it externally into a cylinder, and then rolling it out of the water and up the bank.

Technical inventions naturally lead to the invention of new names, but rarely in such variety as the following synonyms, for all of which we cannot, however, vouch, says Science, collected by a daily paper: Vitascope, kinetoscope, phantoscope, criterioscope, cinematograph, biograph, kinematograph, wonderscope, animatoscope, vitagraph, panoramograph, cosmoscope, anarithmoscope, katopticum, magniscope, zeoptrotrope, phantasmagoria, projectoscope, variscope, cintygraph, cinomograph, hypnoscope, centograph, x-ograph, electroscope, cinagraphoscope, craboscope, vitaletiscope, cinematoscope, mutoscope, cinoscope, animaloscope, theatograph, chronophotographoscope, motograph, kinetograph, rayoscope, motorscope, kinetinephone, thromotrope, phenakistoscope, venetrope, virtescope, zinematograph, vitopticon, stinetiscope, vivrescope, diaramiscope, lobsterscope, cormonograph, kineoptoscope.

Plans are being considered for utilizing the herd of reindeer which passed through Chicago on its way to Alaska last winter in carrying the mails between St. Michael and points on the Yukon River. The scheme is said to have originated with Dr. Sheldon Jackson, well known in connection with the Alaskan government service. Mr. P. C. Richardson, of Seattle, has three contracts with the postal department for handling the Alaskan mails. There is a semi-monthly service, for letters only, between Juneau and Weare, at the mouth of the Tanana, taking in Dawson, Forty Mile, American Creek, Circle City, Port Yukon, and Rampart. A second contract provides for a monthly service between Weare and St. Michael. The third contract is for the transmission of 2,500 pounds of mail monthly from Seattle by way of St. Michael to Circle City and Dawson. The distance between Dyea (which is near Juneau) and St. Michael is about 2,300 miles, and between Dyea and Weare, 1,375 miles.

What becomes of all the old copper coins? There are 199,900,000 old copper pennies somewhere. Nobody knows what has become of them, except that once in a while a single specimen turns up in change. A few years ago 4,500,000 bronze 2-cent pieces were set afloat. Three million of them are still outstanding. The million 3-cent silver pieces are scattered over the United States, but it is very rarely that one is seen. Of 800,000 ½-cent pieces, which correspond in value to English farthings, not one has been returned to the government for coinage or is held by the Treasury. Congress appropriates about $100,000 yearly for recoining the silver coins now in possession of the Treasury. These are mostly half dollars, and are not circulated because there is no demand for them. Not long ago the stock of them amounted to $5,000,000, but it is only about half that now. The money set aside for recoining is not intended to pay for the cost of minting, but it is required to reimburse the Treasury of the United States on account of the loss which silver pieces have suffered by abrasion. The loss amounts to $30 on every $1,000, and it has to be made good in order to set the treasurer's accounts right.—Atlanta Constitution.

There seems to be more public curiosity respecting zinc than any other metal. This is due probably to the fact that other metals come more into the daily life and are therefore better understood. According to the most careful estimates, this country produces about 300,000 tons of zinc ore each year, which, reduced to pure zinc, amounts to 80,000 tons, with a cash value of $10,000,000. Probably three times this amount of zinc is imported annually, although a great deal of imported zinc is exported again after having been manufactured into various articles. As an article of commerce zinc is known as spelter. Several of the compounds of zinc make active medicines, although in its pure metallic state it produces no effect on the human economy. It is used extensively for engraving plates, for galvanic batteries, for roofing, and for coating telegraph and other wires. As zinc has a low melting point and moulds desirably with sharp impressions, it is used a great deal for casting works of various kinds, such as statues, statuettes and ornamental designs. One of the most important uses to which zinc is put is the coating of other metals to protect them from the elements. The film of oxide which coats the zinc when exposed to moisture prevents the rust from penetrating the metal, and further oxidation becomes impossible.—Western Mining World.

SELECTED FORMULÆ.

Royal Copper Finish.—The copper coloring is termed royal copper from its intense red color. It is produced by dipping in a solution of 2 drachms sulphide of antimony, 1 ounce pearlash to 1 pint of water, or by boiling the copper articles for 15 minutes in a strong solution of tartar and water.

Colored Aluminum Alloys.—A purple composition is produced by alloying 78 parts of gold and 22 parts aluminum. With platinum, a gold colored alloy is obtained; with palladium, a copper colored one; and with cobalt and nickel, a yellow one. Easily fusible metals of the color of aluminum give white alloys. Metals difficult of fusion, such as iridium, osmium, titanium, etc., appear in abnormal tones of color through such alloys.

Harmless Hair Dyes.—Where, from some personal idiosyncrasy, the color of the hair has disappeared and cannot be restored, a dye may be considered necessary, the following will be of service; but the nitrate of silver dyes should be avoided, and the use of any dye for prolonged time is detrimental to the hair.

1. Brown:

Walnut skins beaten to a pulp	4 ounces.
Rectified spirit	16 "

The above is perfectly innocent in its character. The following is original and non-injurious:

2. Black:

Sulphate of iron	10 grains.
Glycerine	1 ounce.
Water	1 pint.

The hair must be thoroughly washed with this, dried and brushed once daily for three days; then the following should be applied on a small tooth comb, but it should not be allowed to touch the skin if the other preparation has done so, as a temporary stain would result.

3. Gallic acid 4 grains.
Tannic acid 4 "
Water 1½ ounces.

After the first application of formula 2, the hair should be allowed to dry and then be brushed. Subsequently, both formulæ may be used once daily at an interval of an hour or so, until a black color is produced. All preparations of lead and mercury are injurious if used for any length of time; they may, however, be legitimately used where some small portion of hair has, from personal idiosyncrasy, lost its color, which cannot be restored.

Hectograph Ink.—Here are some formulas for inks:

VIOLET.

Methyl-violet	1 part.
Water	7 "
Alcohol	1 "

RED.

Rosaniline	2 parts.
Water	10 "
Alcohol	1 "

BLUE.

Resorcin-blue M	1	drachm.
Acetic acid	6	minims.
Glycerin	25	"
Rectified spirit	1	drachm.
Distilled water, enough to make	1½	ounces.

GREEN.

Aniline green D	2	drachms.
Acetic acid	6	minims.
Glycerin	25	"
Rectified spirit	1	drachm.
Distilled water, enough to make	1½	ounces.

To make these inks mix the liquids, warm and dissolve the dye in the hot fluid. In operating the hectograph the matter to be reproduced is written with the inks upon well glazed paper, and when the writing is dry it is transferred to the pad by placing the sheet of paper face downward evenly upon the pad and rubbing with the hand. Care should be taken that there are no wrinkles upon the paper. Allow the paper to remain upon the pad for about five minutes, then pull it off carefully. Now take a piece of paper of the same size as the original, but not so highly glazed, and lay it upon the pad, going from top to bottom and smoothing it out evenly. A few seconds suffice to take the first copy; then take another, and so on to the extent of forty or fifty; but toward the end much longer contact is required, or slightly damped paper may then be used. When the process is finished rub the face of the pad with a cloth or sponge damped with a mixture of 7 parts of water and 1 part of hydrochloric acid, then with pure water, to remove most of the writing, and set aside for at least 12 hours, when it will be ready for use again.—The Pharmaceutical Era.

To Clean Plaster of Paris Ornaments.—To restore "dusty plaster casts to the original condition of brilliant pure white" is almost impossible. There are several methods of cleaning, coloring, glazing, and bronzing casts. About the best thing for cleaning is, first blow off all loose dust, then sprinkle a little fine dry plaster of Paris reduced to a fine, smooth powder. It must not have any ragged little lumps in it. Sprinkle this over the bust, cast, or other ornament, and, with a dry, soft brush, work the clean plaster gently about, blowing what you have worked with off now and again and sprinkling on fresh plaster, which has a wonderful power of taking up the dust into itself, and finally, if carefully done, leaving the cast very much improved after going through a few turns of blowings, sprinklings, and gentle brushings.—Pottery Gazette.

An Antidote for Cyanide Poisoning.—The Journal of the Chemical and Metallurgical Society, of South Africa, reprints the following from a German exchange: "Practical experience has shown that peroxide of hydrogen may be considered a powerful antidote for cyanide poisoning. It has recently been applied successfully in 2½ to 3 per cent. solution as subcutaneous injections, which were performed every four minutes at different parts of the body. At the same time the stomach was washed out with a 2 per cent. H_2O_2 solution. Peroxide of hydrogen forms with hydrocyanic acid oxamide, which is a harmless compound: $2\,HCN + H_2O_2 = 2\,CONH_2$ = oxamide."—Pharmaceutical Era.

BULL FIGHTING.

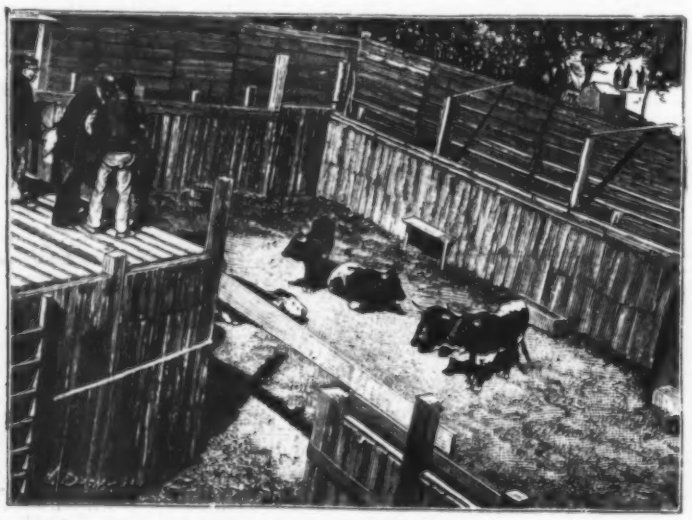
BULL-FIGHTS have become so indispensable an amusement to a great portion of the French population that it is now no longer allowable for a person to be ignorant of the main features of this eminently Spanish spectacle.

The redoubtable bulls are brought from the place of their nativity into the city where they are to see their last day. Here they are placed in a "corral," where the "aficionados" (amateurs or connoisseurs) of the city come to inspect them and judge of their qualities. Every "aficionado" who respects himself must likewise be present at the "prueba," or test of the horses, which takes place on the eve of the fight, and during which the "picadores" try their steeds of the morrow. As for the "toros," or bulls, which are inspected at their points of departure and arrival by veterinary surgeons and the "alcades," or mayors, these must be five years old at the least and seven at the most, and be healthy and vigorous. The animals are put into a "chiquero" (stall) four hours at least before the beginning of the spectacle. This is what is called making the "apartado," and thereat the "aficionados" must also be present. The "toreros," the bull's enemies, are almost all young. The exercise of their art gives them an agility and suppleness that it would be difficult for anyone who has not been a witness thereof to have any idea of. Jumping over the "barrera" that separates the arena from the circular passage ("callejon") running to the base of the rising benches is merely sport to them; and so it is to the bull sometimes!

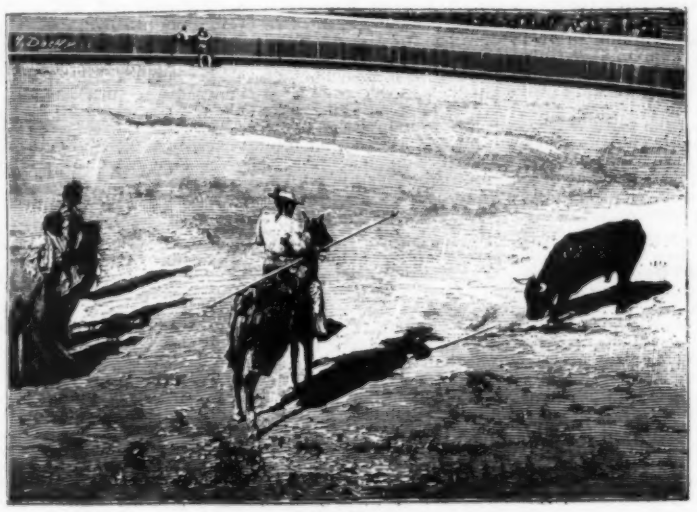
Their smart costume is well known. It consists of a close-fitting vest and breeches richly embroidered with silver or gold, a silk sash and scarf of the same color, a fine shirt, silk stockings, and low shoes. Their headgear, which is black, is called a "montera." One of the peculiarities of the toreros (who wear their hair short and are closely shaved) is that of allowing to grow upon the top of their head a long tuft of hair, which they braid, and which during the fight falls in the form of a sort of chignon from the "montera." This is called a "colleta." Finally, previous to entering the arena, they drape themselves in a wonderful cape of embroidered silk, which they wear with a gracefulness that is peculiar to them. The "picadores," or bull baiters, wear a large sombrero and wide trousers reinforced beneath with the "mona."

cede it. Then come the two "matadors," each followed by his own "cuadrilla," for in a complete Spanish bull-fight there are two "espadas" that alternate in the killing, each working with his own men. The "cuadrilla," properly so called, comprises the "matador," the "banderilleros," and two or three "picadores," without counting the "sobresaliente," who is the second of the matador, and replaces the latter in case he is wounded. Afterward come the picadores upon their horses, the right eye of which is bandaged so that they cannot see the bull, which the picador always attacks at the right. Finally, closing up the rear, comes the train of "arrastre"—three mules harnessed to the Spanish colors, gayly ornamented and noisy with bells. These are led by "chulots," or arena boys, in a modest and uniform costume.

A PICADOR UNHORSED.



BULLS IN THE CORRAL.



BULL REFUSING TO FIGHT.

At the appointed hour, the president being installed in his box, the "cuadrilla" appears, all radiant in silk, all sparkling with gold, and, to the entrancing music of a march, makes its triumphal "paseo" or parade around the arena. The "alguazils," two horsemen elegantly clad in black satin costume of Louis XIII., pre-

The "paseo" finished, the cuadrillas halt in front of the official box and salute the president and the spectators. Then, with their usual gracefulness, the toreros divest themselves of their silk cape and throw it to the lady whom they wish thus to honor, and who spreads it in front of her upon the edge of her box, or upon the gallery railing. One of the alguazils receives in his hat the key of the "toril" (bull pen), thrown to him by the president, and hands it over to the man whose business it is to let out the bull. Then everyone who is to fight, save the picadores and the men of the cuadrilla, retires to the "callejon" or circular passage. The gate of the pen is opened, and the bull, almost always in a furious state, makes his entrance. After this, the "lidia" (fight) with the first bull is begun. Each lidia may be divided into three parts, the first and last of which are indicated by trumpet calls and each of which prepares for the following by progressively fatiguing the animal: (1) The "picadores" or "suerte de varas;" (2) the "banderillas;" (3) the death ("muerte").

WAVING THE MULETA.

The first adversary that meets the bull is the picador, who places himself to the left of the "toril" or pen and at about twenty-five feet from it, and, holding in guard his long pike, or "vara," faces the interior of the arena. This weapon, which is very short and of conical form, is inserted by its base into a wooden disk, so that the animal shall not be severely wounded, but merely pricked. As a general thing, the animal makes straight for his assailant, and it is at this moment that he is "levantado" (aroused), and, with head erect, charges at hazard upon everything that he meets. The business of the picador is to defend his horse as long as possible, by thrusting his "vara" into the withers of the bull and holding him thus in check. It is hardly necessary to say that despite all the skill and formidable vigor of the picadores, the bull is often the stronger and succeeds in disemboweling the poor horse and dismounting his rider. As soon as the latter touches ground, he would be lost did not the "mantellistes" jump in front of the eyes of the animal and distract his attention until the picador, lifted by the "chulos," was out of danger in the "callejon." But many bulls refuse the pike, and in this case the duty of the picador is to pursue the "cobarde" (coward) in order again to offer him fight.

With very vigorous bulls, as many as seven or eight stabs may be given, for the fact must not be lost sight of that the "suerte de varas" is to fatigue the bull by the terrible stress that it requires of him, and also, let us say, by the generous bleeding resulting therefrom. During this part of the fight only the swordsmen and their "sobresalientes" have the right to stand near the picador for the "pases de mantes" designed to disengage the latter. The other men intervene only in case of accident. The place of the men on foot is behind the left stirrup. Each of the picadors must give one stab in alternating according to their order of seniority.

All have the right to give a second if the bull turns upon them.

A blast of a trumpet, given at the order of the president, informs the picadores that they must retire in order to give place to the "peones," or footmen. At this moment, the bull is "parado," and no longer gallops about the arena selecting his adversaries. Before the "banderilleros" (or men who stick small darts with a flag in the bull's neck) come into play, it is customary for the first characters in the spectacle to execute a few "pases de capes;" and it is here especially that is displayed in all its perfection the bold grace of

TORERO ARMING HIMSELF IN ORDER TO KILL THE BULL.

the Spanish toreros. With their inconceivable suppleness and agility they perform wonderful feats.

At this period of its "lidia," the animal, dazzled by these flying capes, nonplussed by the inanity of almost all of its attacks, and not understanding the uselessness of its charges and of its "cornadas," always given for naught, begins to become circumspect and mistrustful. He no longer charges boldly, and sometimes he even retreats before the man who provokes him, since experience has shown him how difficult it is to harm his insatiable adversary. Then the "banderilleros" enter into action provided with their "banderillas." These latter are sticks about an inch and a half in length provided with a very sharp harpoon iron which they are to fix in the withers of the bull. These are ornamented with paper in the form of curls that give them at a distance a vague aspect of spindles. The awkward or unlucky banderillero who places one of these in front or back of the precise place where it ought to be put never fails to get hooted and whistled at.

Nothing is more difficult than to "parear" (pair) well, and nothing produces more enthusiasm among the spectators than banderillas well planted. The placing "al cuarto," "al relance," "all quiebro," "a media vuelta," "al recorte," "al sesgo," "en la silla," and "a topa carnero" are so many different ways to "parear," some more brilliant and more difficult than others.

The method that best pleases the public, although it is not the most difficult, is the placing of the banderillas "en la silla" (upon the chair), in which the banderillero, placed face to face to the bull, rises only when the beast is upon him, makes a "quite" (step aside) and plants the pair, while the bull hits only the wood of the chair. Each banderillero is allowed three minutes in which to place the dart. These combatants succeed each other by rank of seniority.

Finally, let us not leave this question of the "parear" without speaking of the "banderillas de fuego" (fire banderillas.) These are provided with powder and petards which, through a special arrangement, ignite as soon as they are put in place. It will be readily understood that the greatest apathy of a "cobarde" bull can hardly withstand such explosions, which burn him severely.

The "fauve," as they say in bull fighting, has now reached the state of "aplomado," in which he is fatigued and less disposed to spring forward. It is now for the first character, the "espada" (swordsman), to play the last act of the tragedy. The trumpet sounds the death of the bull.

In order to bear the title of "espada," or "matador," it is necessary to have received the "alternative" of a "matador de cartel" on the plaza of Madrid. By this act, a "diestro" (master) recognizes one of his rivals (his sobresaliente, for example) as worthy of alternating with him. He hands to the candidate the "estoque" and the "muleta" with which the new "espada" is to put to death a bull that is to belong to the master. The estoque, or sword of the matador, has a forged steel blade thirty inches in length. The red hilt is very short and surrounded with wool in order that it may be the better held. The muleta is a piece of red cloth fixed to a staff after the manner of a flag. Before attacking the first bull of the three that he is to stab, the diestro, holding the muleta and sword in his left hand, approaches the barrier, at the foot of the president's box, and, taking off his "montera" (cap) with his right hand, pronounces with a loud voice his "brindis," a sort of salute in a few words addressed to the president and the spectators. Then, bareheaded, he walks toward his adversary, the muleta and the sword in his right hand and the blade concealed under the flag. He then executes a series of passes, in which, as in the "redondo," for example, he makes the animal describe a circle around him without moving his own feet.

One of our engravings represents this part of the performance, which is one of the most brilliant by reason of the wonderful skill and coolness displayed therein by the diestro. Like all the other bull-fighting exercises, the "pases de muleta" are numerous, and each diestro makes a specialty of one or the other.

FIRST ESPADA STABBING THE BULL.

But the moment of death approaches. The espada has pulled the sword from beneath his muleta and tries to "place" his adversary. He is allowed fifteen minutes in which to down the animal (unless the latter be not very difficult), "pases de muleta" and "estocada" included.

In order to dispatch the bull as quickly as possible, a stab must be given at a precise point and penetrate to the heart. But it must not be thought that in the eyes of the true "aficionadas" a stab is badly inflicted because it does not immediately kill the bull. There are "pinchazos" (simple punctures) that scarcely pass through the skin, and yet that are applauded because they are made at the proper point. There are also an infinite number of stabs, of which the name and value differ according to the method employed in giving them. A bull may be struck while standing still or while in motion, and the blade be buried up to the hilt or only half inserted.

The diestro, placing himself face to face with his adversary, aims at his withers and excites him with the muleta to lower his head and rush at him. In most cases, the animal, allowing himself to be deceived, falls upon the muleta in lowering his head in order to give a blow with his horns, and thus exposes his withers and is stabbed, while the espada makes a sortie upon him on the opposite side, and avoids the horns by a slight twist of the loins.

Even in case of a perfect stab, it is rare that the bull dies immediately. In order to abridge his suffering, the "descabello" is employed. The matador makes him lower his head (if it is not already lowered) and punctures him between the horns, at the origin of the cerebellum, and his death is then instantaneous.

In most cases, however, the bull falls still living, and the "puntillero" gives him the finishing stroke. This is generally a "banderillo," who, slipping behind the animal, pierces its brain with a cylindrical poignard called a "cachete."

Up to the death of the animal its conqueror remains in front of it, presenting to it the muleta, while the entire crowd stamps and shouts its admiration in interminable bravos, and throws canes, cigars, fans, and hats. If the master has surpassed himself, the ear of the bull is accorded to him by the president, who thus marks the general satisfaction.

TORERO DOING HONOR TO THE BULL.

Then, to the sound of cracking whips and of bells, enter the mules of the "traina de arrastre," with their drivers. In the twinkling of an eye these are hitched to the cadaver of the bull and drag it out of the arena. The bodies of the horses disappear in the same way, and then the "chulos" scatter sawdust over the blood, and the ring is ready for another fight.

For the above particulars and the engravings, we are indebted to Le Monde Illustré.

WAGES AND PRICES IN AMERICA.

IN the rise or fall of wages and in the variations of the purchasing power of a dollar we have a phase of the monetary and industrial problem. In a recent investigation made by the State Bureau of Massachusetts some valuable information has been secured regarding the ups and downs of wages and prices in that State. The following table gives the weekly wage rate in such industries where the comparisons extend to 1872:

Average Weekly Wages.	1872.	1881.	1897.
Blacksmiths	$16.44	$16.38	$16.00
Boots and shoes	12.71	11.06	11.90
Building trades	15.66	11.00	15.83
Cabinet making	14.21	11.51	13.02
Carpetings	4.89	5 94	8.26
Carriages	17.31	13.43	13.51
Clothing	9.71	10.90	9.01
Machinery	13.84	16.48	10.80
Metals and metallic goods	6.06	13.42	9.51
Paper	7.37	9.47	9.31

In commenting on this report The Springfield (Mass.) Republican editorially says:

"In six of the nine industries specified average wages

are lower to-day than in 1873. Agricultural wages per month with board were $23 in 1872 and $18.50 in 1897. Cotton mill wages are given as $7.59 weekly average in 1881 and $7.71 in 1897, the latter returns having been obtained prior to the general 10 per cent. reduction of last winter. Compared with 1881, wages are more generally higher, and this is true not only of the industries mentioned above, but of others, such as the woolen manufactures, straw goods, stone cutting, rubber goods, printing, and glass making. In hosiery and leather wages are lower than in 1881. Wages, as a rule, were lower in 1860 than in 1872."

These figures, of course, are more or less affected or modified by local or special circumstances, and are not conclusive as to conditions elsewhere. They are, however, in a general way, indicative of the trend of wages in nearly all industries. The tendency in the majority of trades has been downward since 1872, with the added fact that more is being done for the same money now than then. Work is done under higher pressure, and the turnover of products is much more rapid and larger. This fact accepted, the vital point of the question lies in the increase and decrease of the purchasing power of the wage paid to labor.

In a tabulation of twenty-two articles of food, clothing, and that of rentage or housing, it is shown that the dollar of 1897 will buy more in ten cases and less in twelve than in 1860, but as compared with the prices of 1872, one dollar in 1897 will buy less in only one case. In some manufactured articles, such as boots, flannels, shirting, cloth, etc., the purchasing power of the dollar has largely increased, in some cases to twice its value, since 1872.

The conclusion reached by a fair comparison of wages and prices is that, as a whole, the toilers of the country are moving onward to a higher style of living, have more comforts at less cost than those of a few decades ago, are better clad and housed, and, in comparison with the industrial classes of some European countries, the American mechanic and laborer, if not in clover, is certainly not in straw. This is not saying that in some lines of industry wages are miserably inadequate, or the pressure of toil abnormally severe, or that wages and prices are not occasionally manipulated by unscrupulous parties for personal or corporate aggrandizement, or that the problem of the unemployed is less grave or menacing than heretofore. For all of this, however, the bulk of the people are moving in line to better conditions.—The Age of Steel.

THE NEED OF COLLEGE MEN.

AT this season of the year, when we are sending forth so many men from our colleges and technical schools to take up the burden of life and do their work in the world, the question must often arise whether there is room for all these doctors, lawyers, engineers, and architects, and whether we are not robbing the workers, to make poor professional men or needless directors of industry. A study of industrial progress, to turn our thought in this direction, will show that the last few years of progress, the last half of this active, growing nineteenth century, has been one of application of thought to the development of material things. It is not altogether that the world is more thoughtful or men brighter to-day than our fathers were, but that a different direction has been given to thought. In the good old days liberal education meant only a study of classics and pure mathematics. What were called the "humanities" and poetry, literature, eloquence, were the highest attainments of the educated man, and if practical expression was to be given to his work, it was to be found in the law or ministry. In those early days it was beneath the dignity of the educated to soil his hands or demean his talents by devoting them to a study of industry or practical invention. He might be a philosopher, but his philosophy was untarnished by the grime of the shop and his inventions were mechanical playthings, never intended to be harnessed to the wagons of commerce or to be thralls of industry.

The genius of the present age is actuated by quite a different sentiment from that of the muse of the past, and, as a consequence, although we may perhaps lack some of the sentimentalities of life, we certainly have learned to enjoy a larger share of its comforts. But to return again to the college and its work. What is to be done with this army of men who are yearly coming forth from its shades of culture, trained under the new curriculum of science, practical philosophy, and mechanics?

These men are to the industrial army what the West Pointer is to the actual army. They are to be the captains of industry. To-day, engaged as we are in a great war, which we believe to be in the cause of humanity and justice, we find the need of men trained in the science of war to mould our recruits into an army, so we look to these college men to train our workers and give direction to our industries. The school of science, in its present sense, is a modern development, the necessary outgrowth of the demands of a vast industrial population. In the earlier times invention was the accident of circumstance or the development of thought devoted by some practical mind to certain things, but to-day so many of the fundamental mechanical laws have been discovered that, to bring them to the highest usefulness, men trained to mechanical thought are necessary, and invention has become not a mere fortunate accident but the solution of problems presented by the necessities of industrial life.

If we follow these men going forth from our technical schools, we shall find them as the years go by working out these problems in the designing rooms of our factories, studying new chemical combinations in the laboratories of our great iron mills, planning great engineering works for bridging our streams, developing our cities or constructing buildings that will embrace the highest arts of design. These schools have not only the duty of equipping men as mere constructors and inventors, engineers and builders, but also should add the refinements of art to their work. When we have supplied the mere necessities demanded by the times and the needs of men, we must learn to clothe our constructions and fabrications with an appearance which appeals to the sense of beauty.

This is something that the older civilization recognized, and the remains of the great classic races tell us of a high culture in this respect, but, as perhaps might be expected, we, in our earnest efforts to produce the useful, have forgotten the beautiful, and the work of our engineers has had little regard to the scars they were making in the landscape or the obliteration of Nature's choicest scenes by the construction of their bridges. The same thread of thought, or perhaps, rather, thoughtlessness, may be found running through our whole system of industrial design, and creating a crudeness in no way of advantage from the most utilitarian point of view. So far is this from being of advantage that proper proportion, which lends beauty to the eye, is also far more likely to be that best adapted to strength and endurance.

The attainment of that sense which calls for artistic effect in all our work is by no means an early or ready growth in the mind, and can only be brought about by years of association. This association with art work should be one of the provinces of these schools, and if it accompanies the technical work of the three or four years' course, cannot fail to raise the graduates of these schools to a higher standard of culture which must affect their lifework. This specially pertains to the constructive sciences, such as architecture and engineering. In fact, these two are the basis of all branches of design. In some directions we might consider both one. Engineering puts together the framework and architecture clothes it. And if we consider all other arts of design, we cannot fail to recognize a strong reliance on these two. In even the most delicate fabrics the ideas of ornament are derived to no inconsiderable degree from those adopted in architecture, and in adapting these to the work of the loom the engineering faculty is a necessity. Search in every branch of applied arts, and it will be found that the basis of them all lies in these two allied basic callings.

Looking at it from this standpoint, the room for the employment of the men who year by year are passing out from these schools is large, and their training will have much to do with the practical advancement in all art and industry.

No efforts on the part of the State or public spirited citizens can be considered wasted when devoted to these schools. Their graduates, whether they will or no, must be missionaries in this new departure.—Architecture and Building.

FEAT OF AN INDIAN FAKIR.

FEAT OF AN INDIAN FAKIR.

INDIA has often been called a fairyland on account of the wonderful beauty of its buildings, the charm of its landscapes, and its wealth of legendary lore, but it might almost be called a land of magic because of the number of people who support themselves by sleight of hand. The Indian fakirs wander over their vast native land and even through other countries performing their wonderful feats. Recently one of them appeared at Hagenbeck's circus in Berlin, where he astonished the audiences by lifting a boy with his eyelids. The boy made himself as small as possible and was put into a net to which was secured a string that was provided on each end with a little cup just large enough to fit over the eye. The fakir pressed these little cups over his eyes, where they held fast, then threw his head back and slowly straightened his body, thus lifting his burden, which he then carried about—his arms being outstretched all the time—and finally lowered it slowly to the ground again. How is it possible for any man to do this? The only explanation is that the cups were fitted into the eye sockets so that they held on the edges of the sockets, but it is not likely that his trick will be imitated by even those prestidigitators who consider themselves very expert.—Für Alle Welt.

The German government in 1897 received (1,861 or 11 per cent. more) applications for patents than in 1896. The increase is principally in bicycles and sundries (with carriages and harness), where 515 more applications were presented in 1897 than in 1896. In 1892 405 patent applications related to bicycles, in 1897 the number rose to 1897.—Uhland's Wochenschrift.

FORTUITOUS DISCOVERY.

THE accepted principle of necessity being the mother of invention is, like many another maxim, misleading and would be more accurately rendered by substituting for invention the word contrivance or device. The true meaning of the Latin invenire is to come or stumble upon by chance, and in this sense accident alone can claim legal parentage over any fortuitous discovery. Many things of the greatest service to the world in general owe their origin entirely to chance. The rubbing of a piece of amber "evoked," to use Faraday's words, "an invisible agent which has done for mankind far more wonderful things than the genie of Aladdin did or could have done for him;" the up-forcing of the lid of a cooking vessel discovered the marvelous power of steam, and the falling of an apple from its parent stem demonstrated the law of natural attraction. The simple swinging to and fro of a suspended lamp gave birth to the application of the pendulum, to which the precision of modern astronomy owes so much, while the finding of the natural magnet loadstone "did more," said the grave philosopher, John Locke, "for the supplying and increase of social commodities than those who built workhouses."

The manufacture of gunpowder, according to Sainte Foix, was thus revealed. An Augustinian monk, Berthold Schwartz, having put a composition of sulphur and saltpeter in a mortar, it took fire, and the stone that covered it was blown off with great violence, which accident led the chemist to think it might be used to much advantage in attacking fortified places. He accordingly added to it a quantity of charcoal to render it more apt to take fire and increase combustion.

Leaden shot are attributed to a Bristol plumber, who, one night, about the year 1783, "had a dream which was not all a dream," that he was out in a shower of molten lead, which fell in the form of spherical drops. His curiosity being aroused, he went next day to the top of a church and poured some melted lead into a vessel of water lying below. To his great delight, he found that the lead formed into beautifully formed globular balls, and he at once took out a patent.

The inference that glass was discovered by accident is strengthened by the fact that it is scarcely possible to excite a fire to sufficient heat for metallurgical operations without vitrifying parts of the bricks or stones of the furnace.

A Nuremberg glass cutter happened to let some aquafortis fall upon his spectacles, and noticed that the glass was corroded and softened where the acid had touched it. Taking the hint, he made a liquid, then drew some figures upon a piece of glass, covered them with varnish, applied his corroding fluid, and cut away the glass round his drawing. When he removed the varnish, the figures appeared raised upon a dark ground, and etching upon glass was added to the ornamental arts.

According to common report, mezzotinto engraving was suggested by a soldier being observed one morning to rub off the barrel of his musket the rust it had contracted from exposure to the previous night's dew. The observer—whether Prince Rupert or not is one of the doubts of history—perceived, on examination, that the dew had left on the surface of the steel a number of very minute holes, giving the appearance of a dark engraving, part of which had been here and there already rubbed away by the soldier. He therefore conceived the idea that it would be practicable to find a way of covering a plate of copper with little holes, which, being inked and laid upon paper, would undoubtedly produce a black impression; while, by scraping away in different degrees such parts of the surface as might be required, the paper would be left white where there were no holes.

Pursuing this thought, after various experiments, he invented a kind of steel roller covered with teeth, which, being pressed against the copper plate, indented it in the desired manner. The roughness thus occasioned had only to be scraped down where necessary in order to produce any gradation of shade.

One day, nearly three hundred years ago, a poor optician was working in his shop in the town of Middleburg, in the Netherlands, his children helping him or amusing themselves with the tools and objects lying about, when suddenly his little girl exclaimed: "Oh, papa, see how near the steeple comes!" Anxious to learn the cause of the child's amazement, he turned toward her, and saw that she was looking through two lenses, one held close to her eye, the other at arm's length; and, calling her to his side, he noticed that the eye lens was plano-concave, while the other was plano convex. Taking the two glasses, he repeated his daughter's experiment, and soon discovered that she had chanced to hold the lenses apart at the proper focus, thus producing the wonderful effect that she observed. His quick wit saw in this a wonderful discovery, and he at once set about making use of his new knowledge of lenses. Ere long he had fashioned a tube of pasteboard, in which he set the glasses at their proper focus, and so the telescope was invented.

The following year, 1609, Galileo, while in Venice, heard of the discovery, and, being greatly struck with the importance of such an instrument, soon discovered the principle of lenses in a shifting tube, and made a telescope for his own use. To having been the first astronomer in whose hands so valuable a gift was placed, Galileo owed both his reputation and persecution.

Among the many traditions concerning William Lee and the stocking frame is one that he was expelled from the university for marrying, and that, being very poor, his wife was obliged to contribute toward the housekeeping by knitting. It was while watching the motion of her fingers that he conceived how to imitate these movements by a machine.

Arkwright accidentally derived the idea of spinning by rollers from seeing a red hot bar elongated by being passed between two rollers.

The ordinary practice of taking a bath solved for Archimedes the question of how to test the purity of the gold in Hiero's crown. He observed that, when he stepped into a full bath, the quantity of water which overflowed was equal to the bulk of his body, and it occurred to him that the worth of the crown might be tested by such means. He thereupon made two masses of the same weight as the crown, one of gold, the other of silver, and immersed them separately in a vessel fill-

ed to the brim, measuring exactly the quantity of water that overflowed in each case. Having found by this means what measure of the fluid answered to the quantity of each metal, less in the case of the gold than of the silver—the bulk of the former being less, weight for weight—he next immersed the crown itself and found that it caused more water to overflow than the gold, but less than the silver. Having found the difference between the two masses of pure gold and silver, in certain known proportions, he was able to compute the real quantity of each metal in the crown, and thus discovered the fraud that had been practiced on the king, to whom he hurried, exclaiming: "Eureka! Eureka!" ("I have found it! I have found it!") an exclamation that has ever since been used to express exultation over a discovery.

Coming down to our own time, the account of the discovery of saccharine, one of the numerous by-products of the gas maker's refuse, whose sweetness is three hundred times more intense than that of cane sugar, reads almost like a romance. Dr. Falsberg had entered the Johns Hopkins University in order to devote himself exclusively to a study of the chemistry of coal-tar derivatives. Some months had passed, when one evening at tea time he detected an intensely sweet flavor upon his bread and butter. He traced the sweetness to his fingers, to his hands, and to his coat-sleeves; and it dawned upon him that it must have been derived from one of the new compounds which he had that day succeeded in producing. He promptly returned to his laboratory and tasted the contents of every vessel with which he had been working. His idea was correct. One of his beakers contained the sweet material.

Those who are conversant with the fascinating philosophy of Bishop Berkeley may remember the following passage in his "Siris," which, read by the light of present knowledge and the imposing list of valuable substances—oils, dyes, perfumes, flavorings, febrifuges, etc.—now obtained in the process of coal-tar distillation, is almost prophetic: "The virtues of tar-water flowing, like the Nile, from a secret and occult source, branceth into innumerable channels, conveying health and relief wherever it is applied."

Prof. Roentgen came upon his marvelous X rays—which have opened out new fields of research in physical science, besides being of far reaching practical utility in surgery and other departments—quite by chance. He was experimenting in the dark with a Crookes vacuum tube, which was covered with some sort of cloth. A strong electric current was passed through it, while close by was some prepared photographic paper, but no camera. Next day he noticed several lines on his paper for which he could not account. By restoring everything to exactly the same condition as on the preceding day, he was able to ascertain the real origin of these mysterious marks. It is curious that Shakespeare should have written in "Hamlet:"

> Sit you down; you shall not budge;
> You go not, till I set you up a glass
> Where you may see the inmost part of you.
>
> Act III., Sc. 4.

—Home Journal.

A NEW ELECTRIC SEWING MACHINE.

ALL the electric sewing machines that have been constructed up to the present have been driven by a small belt passing over the pulley of the motor and that of the machine. In the new machine that we represent herewith, from La Nature, and which was devised by Messrs. Changy and Kratz-Boussac, the electric motor is mounted directly upon the shaft that effects the necessary movements. As may be seen from Fig. 1, the cam shaft that gives the shuttle and needle the to and fro motion for sewing carries the armature of the motor. Upon the bearing are fixed the brushes that lead the current to the collector. The machine may, moreover, take its current from a collector substituted for an incandescent lamp. It consumes, in fact, but 0·7 ampere at 110 volts at a velocity of 1,000 revolutions a minute. The inductors, which are of forged soft iron, form an intense magnetic field. The armature, which is divided into twelve sections, includes a large number of windings of wire. Upon the frame of the machine, in the circuit of excitation, there is a small rheostat, which, according to circumstances, permits of varying the angular velocity from 180 to 1,500 revolutions per minute.

Fig. 2 shows the complete arrangement of the machine. The apparatus rests through four legs upon a wooden base upon which is fixed the small rheostat just mentioned. The motor, which is supported by the machine itself, enters an aperture formed in the wood. The two back legs of the machine are jointed so as to permit of turning it backward, in order that all the parts may be inspected and the lubrication and necessary regulation be assured.

Upon the right side of the machine the inventors have arranged a wheel, which, through a small internal gearing, allows the apparatus to be run by hand.

We have had an opportunity of experimenting with this machine, says La Nature, and, without being able to appreciate its merits from the viewpoint of sewing, may say that its electric operation is satisfactory, and that its compact form makes it a very practical apparatus.

We must, in fact, in the first place, consider the simplicity of the arrangement, which permits of a belt being dispensed with, and, at the same time, assures a better utilization of the electric energy. Besides, there is no intermediate part to cause sensible losses. We must also remark the machine's light weight and small size, which permit of arranging a large number of apparatus within a limited space and of shifting them about at will.

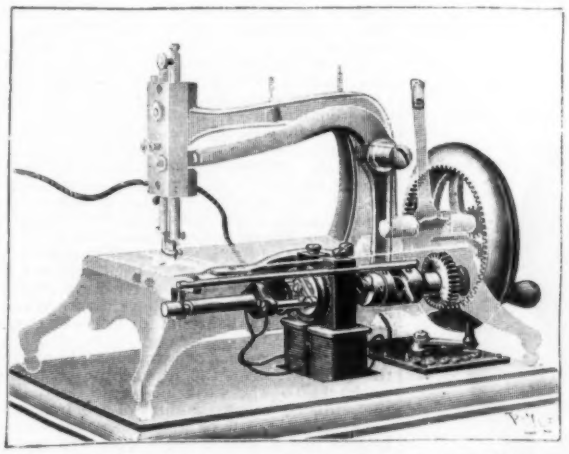


FIG. 1.—A NEW ELECTRIC SEWING MACHINE—INTERNAL VIEW OF THE DRIVING APPARATUS.

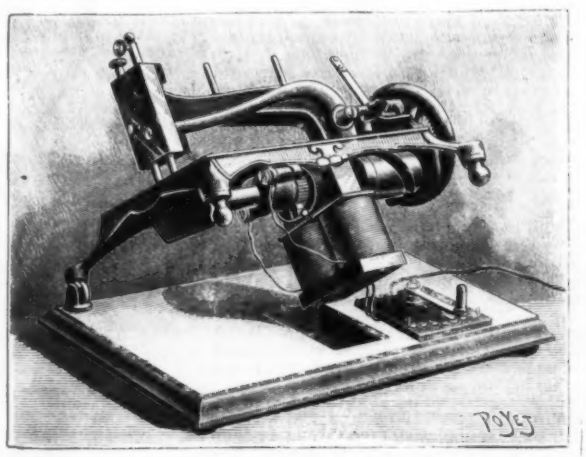


FIG. 2.—THE UPPER PART OF THE MACHINE THROWN BACK—VIEW OF THE PARTS BENEATH.

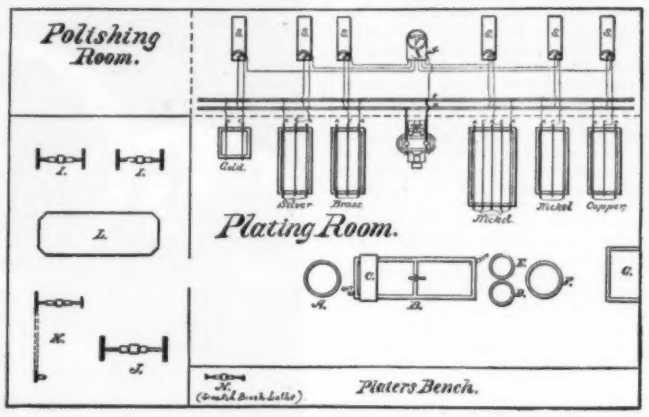
ARRANGEMENT OF AN ELECTRO-PLATING PLANT.*

THE annexed cut represents a model electro-plating and polishing plant of the usual capacity, and shows how the dynamo, voltmeter, switchboards, and tanks should be connected. The plating room should have plenty of light and ventilation, and should be large enough to allow a person to move about freely between the vats. Neither grinding nor polishing should be done in the plating room, as the dust and dirt from the lathes might get in the solutions and spoil them.

According to the directions given by Zucker, Levett & Company, after fixing the dynamo in position, connect the positive binding post of the same, by means of a heavy wire or cable, to the main conductor, *P*, or anode rod running along the wall, and the negative to the main conductor, *N*. Connect the main conductor, *P*, with the anode rods of the tanks. If more than one anode rod is used in a tank, connect them together at the other end of tank, as shown in diagram. From a cathode rod of each tank run a wire to one of the binding posts of the switchboard, *S*. Run a fine wire from the same binding post to one of the lower binding posts of the voltmeter, *V*. From the binding post, *X*, on the right hand side of the voltmeter, run a fine wire to the main conductor, *P*. Connect the other binding post of switchboard, *S*, to the main conductor, *N*. The main conductors, *P* and *N*, should be solid copper rods of large size and the wire or cables connecting the dynamos to same should likewise be large, so as to offer very little resistance to the current. It is advisable to have the wires or cables as large as the holes in the binding posts of the dynamo and the latter as near as possible to the main conductors. The wires connecting the main conductor, *P*, to the anode tank rods, the cathode tank rods to the switchboards, and the switchboards to the main conductor, *N*, should be of fairly good size, though not as large as the main conductors. A good rule to follow when two tanks are used is to have connecting wire one-half the thickness of the main conductors; with three tanks, one-third the thickness; and with four tanks, one-fourth the thickness. Sizes of wire suitable for tanks of 100 gallons or less capacity, ¼ inch; 100 to 200 gallons, 5-16 inch; 200 to 300 gallons, ⅜ inch; for larger tanks, wire in proportion. Where connections are intended to be permanent, it is much better to solder them than to use screw connections. All connecting wires should be of copper, as that metal is a much better conductor than either brass or iron.

If only one tank is to be run, there would be no necessity for the main conductors, *P* and *N*. The positive binding post of the dynamo should in that case be connected direct with the anode rod of the tank, and the negative binding post to one of the binding posts of the switchboard. The other connections would be the same.

To find which is the positive and which the negative binding post of the dynamo, connect a thin copper wire to each end and place both ends in the solution. The wire from which the gas rises is the negative.



PLAN OF AN ELECTRO-PLATING PLANT.

On the opposite side of the plating room should be placed the cleaning and rinsing vats, plater's bench, and boxwood sawdust. A good arrangement of these is as follows:

Starting at one end, first comes the lye or potash kettle, *A*; then a vat, *B*, for cold water. This vat should have running water, with a partition in the center, so that the water runs from one side into the other. The side farthest from the inlet should be used to rinse the work in first, and over this side is placed the scouring board, *C*; then two jars, one for (the cyanide) dip, *D*, and the other for the acid dip, *E*; then a hot water kettle, *F*, and finally a box for boxwood sawdust, *G*. The lye and the hot water are best heated in steam-jacketed vessels, but where steam is not available they can be heated in an ordinary iron kettle by means of a gas ring burner, the kettles sitting on iron tripods. It is handy to have a scratch brush lathe, *H*, in the plating room, especially where gold and silver plating is done.

We herewith give a few important hints: Keep the plating room as clean as possible; cover the tanks and dynamos when not in use; keep the plating room as near 65° Fah. as possible, and on no account ever let it get cold enough to freeze the solutions, or they will be ruined; finally see that all the rods, connections, and wires are kept clean and bright.

A general electro-plating outfit for the plant illustrated in diagram need not cost over $900, and should preferably comprise the following articles:

One No. 4 improved American Giant dynamo, a voltmeter, one 300 gallon nickel plating tank, 5 switchboards, nickel salts for 300 gallons solution, nickel anodes for same, copper rods and connections, connecting wire, a hydrometer, one 100 gallon copper solution tank, 100 gallons copper solution, copper anodes for same, one 50 gallon brass solution tank, 50 gallons brass solution, brass anodes for same, one 25 gallon silver solution tank, 25 gallons silver solution, silver anodes for same, one 4 gallon gold solution tank, 4 gallons gold solution, gold anodes for same, two copper main conductors 1¼ inch thick, connections for same, stringing wire of three gages, Salicornia lye, lye brushes, potash, and hot water kettle, cleaning compound, kettle for cleaning compound, fused cyanide of potassium, enameled iron tank for cyanide dip, powdered pumice stone, scouring brushes, 5 gallons dip

* Written for The Engineering and Mining Journal, by T. Like.

ping acid, jar for same, dipping baskets, and boxwood dust.

The general polishing outfit required in connection with the above need not cost over $160, and should contain one No. 10 lathe, two No. 20 lathes, one No. 30 lathe, one No. 50 lathe, muslin buffs for cutting down, muslin buffs for finishing, canton flannel buffs, tripoli composition, crocus composition, nickel, copper, and brass rouge, silver rouge, gold rouge, emery composition, buff leather wheels, leather covered wood wheels, felt wheels of three grades, emery glue, glue pot and brush, scratch brushes, and satin finish brushes.

The extras would comprise the countershaft for dynamo, $15; countershaft for No. 10 lathe, $7.50; countershaft for two No. 20 lathes, $27; and countershafts for the No. 30 and the No. 50 lathes, costing respectively $15 and $22.

In plating under the usual conditions, the ordinary nickel solution requires an electromotive force of 2 to 4 volts; silver solution, ¾ to 1¼ volts; gold, 2 to 4 volts; brass, 4 to 8 volts; copper, 4 to 6 volts, and tin solution, 5 to 6 volts. The voltage required in any case depends directly upon the composition of the solution, and indirectly upon the amount of work, the metal composition of the article to be plated, and the amount of anode surface in the bath.

At two of the largest bicycle factories in the world, the parts of the bicycle to be finished in nickel are first brought to a certain smoothness at the joints and are then ground and polished until their surfaces are made almost as smooth as glass. Emery powder and walrus hide are staple necessaries for this work. The walrus hide is used to make polishing wheels, and the emery powder is sifted over the periphery of these wheels and held there by glue, so as to offer a grinding surface to the steel. For heavy grinding wooden wheels are used, covered with "oak tan" polishing leather, and this covered again with emery; but where a high degree of polish is desired, nothing has been found to equal walrus hide, which makes a wheel at once tough and sufficiently yielding.

Having been thus polished, the handle-bars, cranks, etc., are first chemically cleaned in vats containing steaming solutions of potash, lime, and muriatic acid, and are then thinly coated with copper in big tanks holding a cyanide solution. The articles to be nickeled are now immersed by the hundred in the nickeling tanks, in which they remain for three or four hours, this being usually sufficient to insure good plating. When taken out the nickeled parts present a dull color, not brighter than silver which has been much used, and by no means resembling the ordinary nickel plating seen on bicycles. Before the parts will take on a high gloss, they must be "buffed down" on peculiar swift turning wheels. These buffing wheels are composed of disks of cotton cloth, 120 of the latter being placed side by side to form a single wheel. One might imagine that wheels of such flimsy stuff would offer small resistance to the steel, but the lathes turn with such great rapidity —2,600 revolutions to the minute—that the centrifugal force drives the flaps of the cotton hard together, so that when the wheels are turning at full speed they form a surface, not as hard as board, to be sure, but quite hard enough for the purpose. And the friction of these wheels against the bicycle parts wears out the wheels so rapidly that much cotton waste and emery dust are thrown into the air that might do harm to the workmen's lungs were they not carried away by the suction of a big exhaust fan. When used in buffing, the cotton wheels are smeared with "white polish," and so effective is the treatment that a few seconds' contact with the rapidly driven wheels is sufficient to bring the finest polish to the nickel—a polish which it practically retains permanently. The nickeled parts are now wiped clean and are ready for use.

AN ALUMINUM CONDUCTOR.

THE aluminum conductors installed by the Niagara Falls Hydraulic Power and Manufacturing Company to carry current from their power house in the gorge to the new factory of the National Electrolytic Company on the high bank above are now in use. These conductors are the first of the kind made. From the power house to the top of the bank these conductors are in bar form. The bars are 25 feet long, ½ by 6 inches in thickness and width, and four are placed in parallel. The bars are riveted and bolted every 25 feet, and they extend from the power house to the top of the bank along the side of the big new penstock, the erection being on brackets. At the top of the bank they are connected to the aluminum cables, twelve of which are on each leg. In diameter the aluminum part of the cables is about 1¼ inches, covered with rubber insulation. The size of the wire in the cables is about No. 10. The bars are connected to the cables by castings, which contain sockets, just holding the ends of the cables. These ends are placed in the sockets and melted tin is poured about them, making a solid permanent joint. The total amount of aluminum used in the installation is about 23,000 pounds. The same work in copper would call for about 48,000 pounds. The conductivity of aluminum as compared with copper in same section is 63 to 64 per cent., and more than double for the same weight.

One important feature demonstrated in the erection of the new aluminum conductors at Niagara was the ease with which they were placed in position, as compared with the work of erecting copper cables. The high cliffs of Niagara at the point of the installation do not offer many advantages for easy placing of materials, but the aluminum conductors, owing to their lightness of weight, were easily handled, and erected with rapidity. While it is a fact that aluminum cables require more insulation than copper, it seems very likely that there is a field for the use of aluminum in feeder cables. There is little doubt but what the extra cost of the insulation would be met by the manufacturers in the price of the metal, especially on large orders. The lightness of the aluminum cable, also its strength, would make it possible to use the aluminum conductor in much longer spans, thus doing away with the cost of the extra poles and insulators now required by copper, which in miles of line is no small factor.

The aluminum conductors referred to are the second set installed by the Niagara Falls Hydraulic Power and Manufacturing Company, thus attesting their confidence in the white metal. The first set of aluminum conductors placed by them runs from the original installation in their station to the lower works of the Pittsburg Reduction Company. These conductors are in the form of huge cables, two in number, with 250 strands in each, insulated. The new conductors are neater in appearance and extend to the top of the bank outside of the penstock, while the large cables referred to run up the cliff through a tower.—The Iron Age.

EXPERIMENT UPON INERTIA.

A RING of thin cardboard is placed upon the mouth of a bottle and a coin is laid upon the top of it in the vertical line passing through the neck of the bottle.

EXPERIMENT UPON INERTIA.

The experiment to be performed consists in removing the ring by a stroke of the finger in such a way that the coin shall fall into the bottle. In giving such a blow with the finger upon the internal portion, *A*, of the ring, as shown in the figure, the coin will infallibly fall into the bottle, but if the ring be struck externally it will be impossible to obtain this result on account of the elasticity of the affair.—From Tissandier's La Physique sans Appareils.

THE DICAIOMETER.*

HERON, in his "Pneumatics," describes a large number of wonderful vessels that were used by the ancients, and, among them, one called the "dicaiometer" (a correct measure), which allowed of the escape of but a definite quantity of the liquid that it contained.

This was constructed as follows: Let us suppose a vessel (see the illustration) whose neck is closed by a diaphragm. Near the bottom is placed a small sphere, *T*, of a capacity equal to the quantity that it is desired to pour out. Through the diaphragm there passes a small tube, *Δ E*, which communicates with the small

THE DICAIOMETER.

sphere. This tube contains a very small aperture, *Δ*, near and beneath the diaphragm. The sphere contains at its lower part a small aperture, *Z*, whence starts a tube, *Z H*, that communicates with the hollow handle of the ewer. Alongside of this aperture the globe contains another one, *Δ*, through which it communicates with the interior of the ewer. The handle is provided with a vent, *Θ*. After closing the latter, the ewer is filled with liquid through an aperture that is afterward stopped up. The tube, *Δ E*, may likewise be made use of, but in this case it is necessary to form a small aperture in the body of the ewer in order to allow the air to make its exit. The globe, *T*, fills at the same time that the ewer does. Now, if we turn the ewer over, leaving the vent, *Θ*, open, the liquid in the globe, *T*, and in the small tube, *Δ E*, will flow out. If we close the vent and bring the ewer to its former position, the globe and the tube will fill up anew, since the air that they contain will be expelled by the liquid that enters thereinto. The ewer being again turned over, an equal quantity of liquid will flow anew, save a difference due to the small tube, *Δ E*, since this latter will not always be full, and will empty in measure as the ewer does; but such difference is very insignificant.

* Copyrighted, 1897, by Munn & Company.—From "Magic: Stage Illusions and Scientific Diversions, including Trick Photography."

ROMAN VILLAS.

THE villa or country house of the Roman gentleman, properly so called, was often built near the sea, because, says Winckelmann, fevers or great heat were not experienced on the coast. The country house discovered at Herculaneum was situated on the edge of the sea, and a long causeway led from the garden to a circular summer house, pierced with windows in every direction and situated in the sea itself. In short, the grand distinction from town houses consisted in the villas being insulated by a moat, single or double, with a wall between the two, or in their inclosing a piece of water. This last, like our modern public gardens, was surrounded with a piazza, divided by columns into boxes for conversation or bathing. Between the columns were placed busts and statues alternately. In general these houses had only one story.

The country houses of Rome (properly defining the term) were villas of enormous magnificence and exquisite situation, but as the great public men could not be long absent from Rome, they had inferior and smaller residences in the outskirts of the city, which they called their gardens, and also villæ, suburbanæ or suburbana. Of course those at Pompeii, being existing specimens, are the fittest to be considered.

These villas present nothing to the road but bare walls. The windows are all toward the garden like the houses of the East. In the center of a square was a bath and ædiculum, the square formed by a piazza, the roof of which was a terrace, and at each end of the hither corners at least was a summer house. The plans were by no means uniform, and according to the Pompeiian villas there is no important difference from the town house, except in the annexation of the garden, inclosed within a porticus or piazza.

The villa on the road called of Herculaneum was placed upon the edge of the declivity, which sloped toward the sea, and consisted partly of two stories, the upper one being on the level of the street. It was spacious, and near the entrance was a bath, with all the necessary appendages. In the rear, the best rooms opened upon a terrace running the whole width of the house, and overlooking a garden or xystus, about thirty yards square. Under the terrace was a portico for exercise in shade or during rainy weather. At the further extremity a small temple, supported by six columns, projected toward the villa, and in its front a bath or basin occupied nearly the center of the garden. The lower apartments, under the arcade, were paved with mosaic, coved and beautifully painted, as was also the greater part of the villa. One of the rooms had a large glazed bow window. The glass was very thick, and deeply tinged with green. It was set in lead, like a modern casement. In the cellars were many large earthen wine vases ranged in order against the walls. In that part of the lower story which was removed from the covered portico the rooms, more simply finished, contained implements of husbandry. To this division of the house was a separate entrance.

The Roman villa was divided into three parts: the urbana, for the master and family, the rustica for the farmer and husbandmen, and the fructuaria, or storehouse for corn, wine, and oil. The servants who were immediately attendant upon the master, and belonged to the villa urbana, were the atrienses, or what the Italians style the sala, in speaking of the livery servants collectively; the valets, cubicularii, who, it is presumed, were usually freedmen; the secretary, styled notarius; the gardeners, for the pleasure garden, topiarii, and the musicians and comedians and persons for entertainment during repasts. This villa urbana, also denominated pseudo-urbana, and prætorium from obvious distinction, had a peristyle or court, surrounded by a portico, at the further extremity of which, opposite to the gate of entrance, was the atrium or hall, with a portico on each side, looking toward the place of exercise, as lawns, galleries for wrestling, and other smaller buildings. The baths were also annexed to this part of the building, and were always so situated as to enjoy the winter's setting sun. Besides the sitting rooms, chambers, library, and dining room—they would often have one of the latter kind, in the midst of the park, as we should call it—and sometimes a bedroom for the sake of quiet and retirement.

In the villa rustica or farmhouse, in apartments over the gateway, lived the procurator or steward, that he might know who went in or out; on one side of this, the villicus, bailiff or chief of the husbandmen, and near the fructuaria or storerooms, the villica or housekeeper, under whose order were the female servants employed in providing food and clothing for the family. The inferior slaves lodged in one great room, and the sick in an apartment called the valetudinarium. The lodgings of the freedman had a southern aspect. The aviarius had the care of the poultry, and in considerable villas, far from a town, was a master of the workmen, ergastularius, with smiths and carpenters under him. Horses and mules were kept for the use of the master, and asses and oxen for that of the farm, which had yards much resembling the modern. Particular care was taken of the geese, hens, pigeons, peacocks, and other birds, who had also separate dwellings assigned to them; and not only deer, hares, and every kind of game was attended to, but there can scarcely be named an animal which was not kept by the more opulent Romans at their country seats.

The villa urbana or pseudo-urbana was also divided into a winter or summer house, because it had a suit of rooms adapted to either season. The parts which

composed the summer residence were nearly the same as those of the town, except that the dwelling apartments, which did not commonly exceed one story, were always surmounted by a tower, on the top of which was a room pierced with windows on every side, uniformly destined for meals, so that they could add to the pleasures of the table those of light and prospect. They nearly always built their villas along the high roads for two reasons, one to get to them more easily, the other to place them more in sight. In the Pompeian paintings we have villas of this kind. One on the seashore of two stories has trees planted on the roof. Winckelmann says that the architecture of the villas of Herculaneum is the same as that of the large houses of towns, so that the plan and elevation of the one is the same as that of the other.—The Architect, London.

THE LIVER.

THE liver is the largest gland in the human body. It is arched on both surfaces, the upper, however, which adjoins the under surface of the diaphragm, being more so than the under, so that the organ is

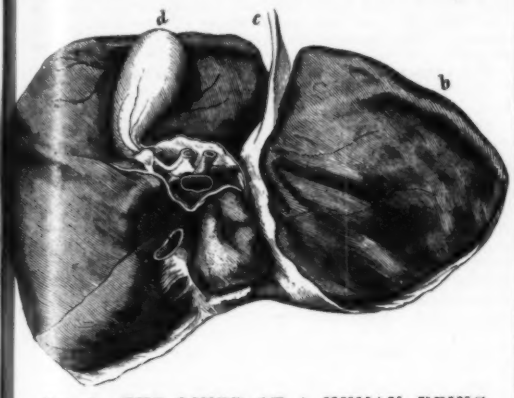


FIG. 1.—THE LIVER OF A HUMAN BEING.

a, the large right lobe; *b*, the small left lobe; *c*, the lobus quadratus; *d*, the gall bladder.

thick in the middle and tapers off toward the edges. It is divided into a large right lobe and a smaller left lobe, separated by a fissure along the under side; a similar fissure lies farther toward the right on the under surface of the right lobe. These two fissures, which are not exactly parallel, are connected in the center by a transverse one, the "porta," through which arteries, veins, nerves, and gall duct enter and leave, and from this the largest of the entering blood vessels takes its name, viz., the vena porta. The gall bladder lies in one of the fissures on the under side of the liver; is pear-shaped, the thicker end projecting beyond the front edge of the gland. In the posterior portion of the same fissure lies the inferior vena cava, which passes from the abdominal cavity to the heart.

In the fœtus, between the right and left lobes, lies the large umbilical vein which passes from the cord through the navel, joining the inferior vena cava at the posterior edge of the liver; after birth this dries up, and only a solid cord remains, which runs from the anterior edge of the liver to the navel.

Likewise the liver is inclosed by a firm membrane, and the organ is also, for the most part, covered by a continuation of the peritoneum, the sac that lines the

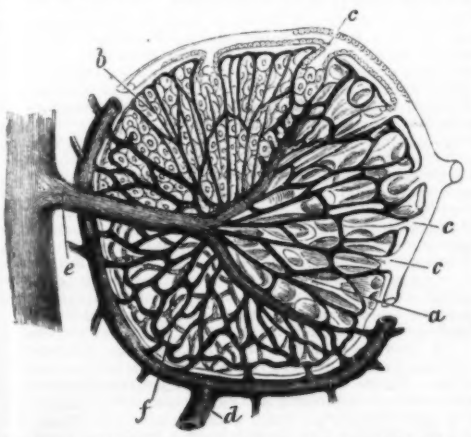


FIG. 2.—REPRESENTATION OF A LOBULE.

a, spaces in the network; *b*, a part filled with lobules; at *c* is seen the beginning of the lobule ducts in open connection with the spaces; *d*, last branch of the vena porta; *e*, root of the hepatic vein; *f*, the lobule network of capillary vessels.

abdominal cavity. Besides the large hepatic artery, the great vena porta, formed by union of the intestinal veins, enters the liver through the porta, beside the biliary duct that passes outward. The latter goes directly to the duodenum, but also sends a branch to the gall bladder. Thus the biliary fluid, in case either branch is closed, empties directly into the other. Ordinarily it collects in the gall bladder, then flows into the intestines.

In many mammals, such as the hog and the polar bear, in the upper portion of the liver so-called hepatic lobules or liver cells will be noticed (Fig. 2), separated one from another by narrow ridges; and their centers sometimes are dark reddish brown and the peripheral region light yellowish brown. Again the conditions are reversed. These differences depend chiefly upon the supply of blood. Between the cells is the interlobular substance, and where the cells are distinctly divided from one another—as in swine—on analysis are found to consist of a cell envelope forming capsules and the branches respectively of the vena porta, the hepatic artery, and the biliary duct. The dark dividing lines between the cells generally indicate their thickness, but the separation of cells is incomplete, as in the human, the intermediate substance, though not lacking, cannot readily be traced or its thickness determined.

Each cell or lobule consists chiefly of numberless glandular cells and a generally permeating highly developed network of capillary blood vessels uniting in the center to form the hepatic vein; external branches

FIG. 3.—HUMAN LIVER CELLS.

a with one, and *b* with two nuclei.

of the vena porta and fine gall ducts indicate the boundaries. When small particles of liver substance are viewed under the microscope, some cells are found isolated and some are grouped together in considerable numbers in rows or in irregular masses. These cells were first described in 1837 by Purkinje and Henle. They are irregularly formed, flattened by pressure, and provided with a small, yellowish, core-like protoplasm rich in albumen, in which there is a large, round, bubble-like cell nucleus with one or two kernel-like bodies (Fig. 3).

In the cells, generally, are globules of oil and little particles of yellowish red coloring matter. In mammals, for instance, the amount of oil or fat is perceptibly increased by certain diseases and also by an increase of fat in the nourishment; and sometimes the

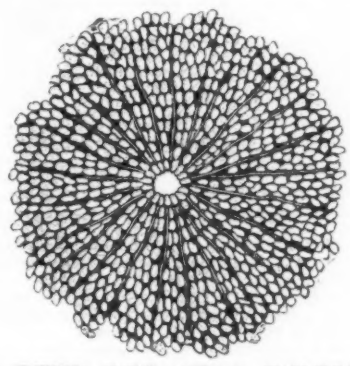


FIG. 4.—LIVER CELL OF A TEN-YEAR-OLD BOY.

Showing section through the central branch of the hepatic vein.

separate globules unite to form larger globules. Again, the fat may increase to such an extent as to entirely fill and greatly enlarge the cell, completely covering the nucleus. Fatty livers are common among high livers. The flattened surfaces of the cells lie close together, so that they form a solid network which is particularly regular around the central vein from which they radiate (Fig. 4). The width of the network of cells depends upon the spaces between the capillary vessels; sometimes there is one row of cells, one behind the other, and two to five cells broad, but the form is always variable, owing to the irregular arrangement of the capillary vessels and the intervening spaces.

To fully understand the construction of the organ, the peculiar offices of the blood vessels must be con-

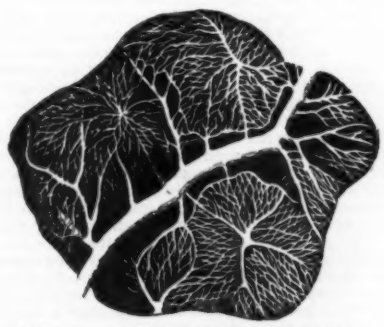


FIG. 5.—LIVER OF A RABBIT.

With branch of vena porta, the venæ intralobulares, the main network of vessels and the hepatic vein in the center of the lobule.

sidered. Blood enters through both the hepatic artery and the vena porta, the greater quantity through the latter. The hepatic artery serves chiefly to nourish the organ, as was demonstrated by Hering. Its branches run continuous with those of the vena porta and of the biliary ducts, extending over the walls of both; some even extend to the serous covering of the organ, forming a wide meshed, hair-like network. All venous outlets are embedded in the ramifications of the vena porta, and the end branches of the latter form what Kiernau terms venæ interlobulares (Fig. 5), which are little branches of from 0·0338 to 0·0451 millimeter diameter, and that may be shorter (as in human beings) or longer (in rabbits), and then form arched vessels, or sometimes, as in swine, they form perfect rings which surround the periphery of the lobule or cell. In the interior of the lobule the venules unite to form branches of the hepatic veins, which, of course, originate at the center of the lobule, 0·5640 to 0·0677 millimeter. There are no valves in the hepatic veins.

The simplest assumption is that in the liver (as in other glands) the separate cells are inclosed in an enve-

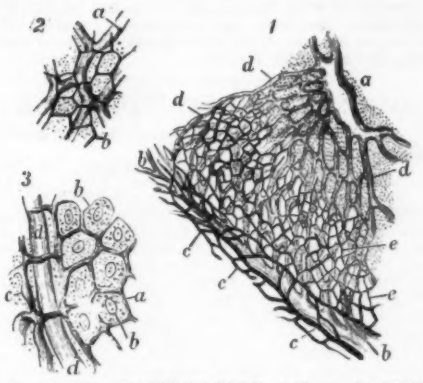


FIG. 6.—GALL CAPILLARIES OF A RABBIT'S LIVER.

1. Part of a lobule: *a*, hepatic vein; *b*, vena porta; *c*, gall ducts; *d*, capillaries; *e*, gall capillaries. 2. *b*, the gall capillaries, and *a*, their relation to the blood vessels. 3. Gall capillaries, showing their arrangement in the lobules: *a*, capillaries; *b*, lobules; *c*, little gall ducts; *d*, blood capillaries.

lope, the epithelium, which opens into the biliary ducts. The gall ducts pass into the interior of the liver with the offshoots of the vena porta and the hepatic artery, and, dividing into branches, finally disappear in a delicate network in the peripheries of the lobules, having lost almost all connection with one another.

It is easy to see how the branches of the gall ducts, with those of the vena porta, scatter among the lobules. From the former (Fig. 6, 1) spring thin-walled, fine bile canals, which cover the ramifications of the vena porta (*b*) and turn inward, forming a network of the finest vessels, the gall capillaries (*d*), which runs all through the lobule. These are most minute canals interwoven in a system of very fine meshes (3 *a*) around the separate cells or lobules (*b*), so that the surface of each cell comes in contact, at one point or another, with this system of vessels, which presents the same aspect from every point of view; and the whole is wonderfully delicate and constitutes also network between that of the blood capillaries and the cells. Hering recognized the connection between the biliary ducts and the biliary capillaries, as well as the relation of the cells to the same. The finest gall canals run, without any perceptible diminution of their diameter, into the gall capillaries.

The liver of the batrachia is very similar in construction. The long gall canals lie like an axis between the two rows of liver cells, and outside of them the

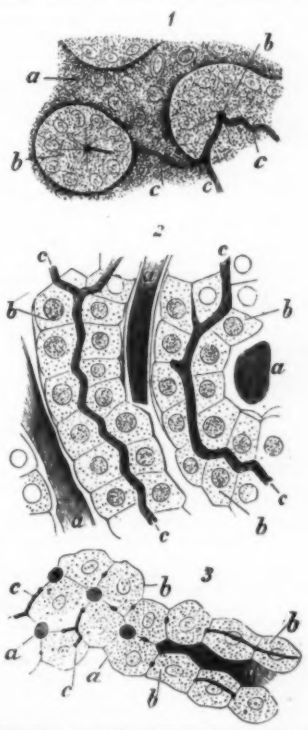


FIG. 7.—FINEST GALL DUCTS IN THE LIVER.

1, of the ring snake; 2, of the salamander; 3, of a rabbit: *a*, blood vessels; *b*, lobules; *c*, gall capillaries.

blood capillaries. As a rule, in all lower vertebrates gall capillaries seldom have side ducts, and it seems to be impossible to deny the existence of blind endings. This side system of branches reaches a considerable degree of development in the birds, and its acme in the mammals, as shown in Fig 7. Here the surface of each cell comes in contact with one or more gall capillaries; but even in the most difficult forms the fundamental plan is the same (Fig. 7, 3). Gall canals (*c*) and capillary vessels (*a*) never come in contact, but are always separated by either a whole cell or part of

one; while in the lower vertebrates several cells surround the former, the contact of fewer and finally of only two is sufficient to form the finest canals.

In the gall ducts there are numerous little grape-shaped pituitary glands. The liver is also rich in lymphatic ducts which form a superficial and deep network about it and accompany the vena porta to the lobules, where they continue as a fourth network which passes through the whole lobule. The numerous nerves of the liver, which are branches of the sympathetic, are very numerous and contain many ganglia cells. In some cases nerve fibers that contain marrow are connected with the lobules by means of fine fibrils which enter the cells, and sometimes bundles of the finest fibers are connected with it.—Schweiger-Lerchenfeld in Der Stein der Weisen.

DRINKING WATER AT CAMP THOMAS.

CHICKAMAUGA PARK, GA., August 23, 1898.

To General J. P. BRECKINRIDGE,
Commander Camp Thomas,
Chickamauga, Ga.

Dear Sir: I had the honor to present myself to your camp, bearer of letters from Gen. Sternberg and Gen. Ludington, to investigate the workings of the water filters which are now in use at Camp Thomas. You have most courteously received me and afforded me every facility; you have placed me in communication with Col. Van R. Hoff, chief surgeon; Col. Wheeler, acting chief quartermaster; and Maj. Parker, attaché to your headquarters as inspector of sanitation; and you have invited all the commanding officers and head surgeons to meet me at your headquarters to hear my explanations and see experimental demonstrations as to the best way of dealing with the water supply of Camp Thomas.

First, in company of Dr. Jenne, then of a member of the quartermaster's staff, and lastly of Maj. Parker, I have visited many parts of the camp, notably the 2d Arkansas, 5th Missouri, 2d Nebraska, 1st Pennsylvania, 14th New York, 2d Kentucky, and 12th New York (Maj. Parker's own regiment). We have also seen some of the hospitals, some of the outposts, and paid particular attention to the wells, pumps, and arrangements initiated by the different regiments for the purification of their water supply.

I have read the report made to you by Maj. Parker, and my attention has been particularly drawn to the nature of the soil and to the quality of the pump water. Nearly the whole camp is on a magnesian limestone. The surface water has no chance of filtering and purifying itself; somewhat as in sandy soil, it passes directly through sink holes, cracks, and fissures into the small water pockets struck by the so-called artesian wells, which, after a freshet, or when much used, give turbid water. Maj. Parker has already pointed out the danger of drinking this water (whose only good quality is that of coolness) from a bacterian point of view. I wish to draw your attention to another defect, less known in this country, but which twenty years' experience in the matter of water supply in England and France has revealed to me.

This pump water, as also that of most springs in limestone formations, is very hard. It does not dissolve the soap, it does not cook the food properly. This is known to everyone; but what is less known is the effect of such water on nutrition.

The Medical Congress of Brussels, in 1886, passed the following resolution:

"Les eaux trop calcaires ou contenant des matieres minerales, avec le chyle, un milieu anormal pour l'hematose (formation du sang). Elles fatiguent les reins charges de les eliminer sans cesse et incrustent les articulations."

"Waters that are too hard, or contain mineral matters that are not in the human organism, form with the chyle an abnormal medium for hematosis (formation of blood), and they fatigue the kidneys, whose duty it is to eliminate them unceasingly, and they incrust the articulations."

A simple way of seeing the effect of hard water on the act of digestion is this:

Take white of egg in two test tubes (about one-sixth full), add about as much bile (taken from a freshly killed animal) and agitate. To one of the tubes add distilled rain water or spring water that has been softened (as will be hereafter explained); agitate. The emulsion will be perfect and readily assimilable. *Being perfectly soluble*, it will pass into the blood and give strength.

To the second tube, add some of the untreated spring water or hard well water, and agitate. The contents will coagulate into lumps and will be no more capable of nourishment than a stone or a sponge.

I submit that the hardness of the spring water has had a great deal to do with the emaciated state of the men, who, without any bacterian disease, have gone down fifteen, twenty, or thirty pounds in weight. This, added to the fatigue and other troubles of camp life, has contributed to make the men weak and unable to resist the onslaught of the typhoid and malarial germs.

In the sick lists I have seen a great deal of lumbago and rheumatism. I submit also that this trouble is in a great measure due to the hardness of the water.

In Camp Thomas you have all the types of water likely to be found anywhere; and, although the camp is going to be temporarily abandoned, the same conditions will present themselves elsewhere, and it may be of interest to take stock of the attempts that have been made to purify the water. We will, I think, find therein the elements of a satisfactory solution of this most important question.

It was at first thought that the combination of asbestos and porcelain filters, given to companies, would insure a supply of sterilized water. And so it would, if they had had to deal with ordinary water; but at the moment they were put in use, from the 7th to the 15th of July, the creek water, which was then distributed into the camp, was in its worse condition on account of continuous freshets, and it was more like liquid clay than water. It clogged the filters so quickly they had to be cleansed so frequently that some of the commands gave up the operation in despair.

I am sorry that I was not aware of this fact at the time, as I would have indicated what I had the pleasure of showing you and the general officers of your command on Sunday, namely, that by adding from one-half to one part of lime and iron to one thousand parts of water, such as that of the Chickamauga Creek, a heavy precipitate is formed, which in less than an hour agglomerates and carries down all the finely suspended clay, like the white of an egg clears coffee.

No objection can be made to the use of lime or iron. They neutralize one another; they sterilize the water, which, on being put in the asbestos filter, passes freely and becomes perfect drinking water.

Let me at this stage offer a suggestion that a waterworks be erected at the creek pumping station, where enough water for the whole camp could be purified, as shown above, and distributed everywhere in pipes laid lower down in the soil than that now existing, so as to give a little coolness to the water.

Finding the creek water too bad to be treated by filtration, you have caused water to be hauled from different springs, wells, and pumps and distributed to the different regiments. But, bright and sparkling as it may be at the source, by the time it reaches the camp it has been sorely polluted. A common old canvas sack is stretched over the open end of the barrel, under the movable lid, to prevent the water escaping when going over uneven roads. These sacks are often on the ground, at other times on the floor of the wagon, and during the whole way (from three to five miles) the spring water in the cask washes the sack and becomes turbid. A wooden or oak float would be better; but, better still, would be a closed water barrel with just a man-hole at the top end. The water could be siphoned instead of being dipped, as now. Such casks to be sterilized at least once a week with milk of lime.

Even when these precautions will be taken, and when this spring water will be delivered as beautiful as crystal, it will still be *hard* water.

You have ordered all water to be boiled, and many are the ingenious contrivances designed by different officers to carry this into effect; but boiling, as it is now done, does not precipitate more than a fraction of the mineral salts. To precipitate all the bicarbonate of lime takes three hours; the sulphate of lime and magnesia are not precipitated by boiling. That is why the hardness due to the latter is called "permanent."

Boiling, therefore, while affording security against microbian diseases, does little or nothing as regards those due to the introduction into the body of *liquid stone*.

Practice and science may again come to our help.

Let the water from each spring be examined *chemically*. It will then be easy to know the exact quantity of hydrate of lime (or common quicklime) to add to the water to precipitate the whole of the bicarbonate (Clark's process) and the exact quantity of carbonate of soda (common washing soda) to decompose and precipitate the sulphate of lime and magnesia (leaving in the water only traces of sulphate of soda).

The writer, Dr. Burlureaux in Paris, Dr. Ray-Lankester in England, and many others, have shown that this chemical treatment, which is applied in England to numerous cities and innumerable estates, asylums, and other establishments, has the effect of *sterilizing the water*.

But we need not insist on this point, as the practice of boiling with a view to sterilization has now become a generally accepted one.

If the water is deprived of its mineral salts by chemical reactions, and boiled, all objections against the water supply of the camp will be met.

Even when boiled, if the water has not a pleasant appearance, it will raise suspicion in the minds of the boys, and indeed they will have no proof that it has been purified.

So all the commands who have started boiling have arranged to filter the water, while hot, through the asbestos filter, and they have a beautifully bright and agreeable water, which, being cooled with ice, at the cost of fifteen cents per man per month, gives a pleasant drink.

The first command to carry this complete scheme into effect—boiling, filtering, and cooling—is the 2d Arkansas, Companies A, B, C, and D. They put their four filters together; the water is boiled in a coil laid on a wood fire and connected with a barrel, from which the water is taken when boiling and passed through the filters into a clean barrel, where it is superb. It is iced in the companies' tents. Since Capt. Wing, Co. A, has inaugurated this plan, August 6, he has not had one man to send to the hospital for fever.

The 5th Missouri has lately erected three similar coils and three boiling barrels. But the most complete and perfect installation which I have seen is that of the 12th New York (Maj. Parker's own regiment).

The boilers recently distributed (square boxes of about one cubic foot) are put in a row on a wood fire; the water is carried boiling into the casks, posted on a stage—four in a row—the boiled water falls through wooden spigots into as many Maignen's asbestos filters, and by siphon the filtered water goes into four other casks in which ice is introduced. Each company provides a man doing no other duty, and four companies filtering together, the men can relieve each other in their surveillance. A sergeant is detailed to look after the water supply, and that only; he has to see that the water comes to the filter stand, that it is boiled and filtered, etc. By this arrangement the boiling goes on once in the morning and once in the afternoon, and the filters work day and night without any other attention than that of filling the top casks and regulating the wooden spigots. Once a day the outer asbestos cover of the filters is removed and washed like a handkerchief. The other asbestos cloth that surrounds the charcoal is sponged. Thus, one battery of four filters is sufficient to clarify eight barrels of boiled water.

If the 12th New York were to put a little lime and soda in the water after boiling, in the casks in which they put it hot, to remove the lime salts, they would solve the problem in a most perfect manner, thus rendering a water that is hard and may have contained typhoid germs, sterilized and agreeable drinking water, which, when brought down to a cool temperature, would be much appreciated by the men.

The 14th New York, under the enterprising command of Col. Wilder, has erected a distilling apparatus of sufficient capacity for the whole regiment. It consists of an upright tubular boiler, the steam of which is to be condensed in coils laid horizontally in a large wooden tank on a four-wheeled vehicle. If the regiment remains close to the creek water pipes, it will settle the question of giving water exempt from mineral salts and microbes; but away from an ample water supply for condensation, the operation will be more difficult. If the hard spring water is put into the boiler without previous softening process, it will fur the tubes.

As a conclusion of the investigation which I have, with your kind encouragement, carried on during my stay at your headquarters, I would say:

The terrible increase of sickness which has caused the camp to be abandoned has had the water supply for the main, if not exclusive cause.

The continuous rain of July has washed the microbe-laden atmosphere and polluted soil, and carried the morbid material down through sink-holes, cracks, and fissures of the rocks, into the pockets of water struck by the pumps.

The far-fetched spring water has been soiled by the dirty canvas bags and muddy bottoms of pails used to empty the barrels on the military wagons. This would account for the malarial and typhoid cases.

The loss of vitality to so many men, the lumbago and rheumatism and stomach disorders, are due, for the most part, to the *hard* water of the pumps and springs. The remedy for this state of things is in our hands.

Have the creek water precipitated before filtering.

The hard spring or pump water softened before boiling, filtering, and cooling.

These operations seem best carried out by battalions as a unit, and can, if need be, also be done by single companies with the apparatus now on hand.

As ice cannot always be procured, the only desideratum that remains to be satisfied is a cheap means of cooling without ice. When this is known by inventors, the apparatus will soon be forthcoming. With these precautions I see no reason why the National Park at some future time, after suitable disinfection and proper sanitary arrangements for the disposal of excreta and other waste, should not be first-rate camping ground. I am, dear sir, yours obediently,

P. A. MAIGNEN, Engineer.

1310 Arch Street, Philadelphia, Pa.

THE SIGNIFICANCE OF THE GARMENT.*

By ALICE C. FLETCHER.

THE data upon which this study of the significance of the garment, including all regalia, is based have been taken from the religious observances and rituals, the social usages, and the individual habits of the Omaha Indians and their cognates. Many years of close personal relations with these people led to a familiarity with their customs and modes of thought, enabling the writer to come nearer to their point of view upon various subjects than could otherwise have been possible. Because of these peculiar advantages enjoyed during years of original research, this paper was offered as a contribution to the study of a subject which has engaged the thoughtful attention of many writers.

The sacred legend of the Omahas recounts the history of the people from the time that they "opened their eyes and beheld the day" to the complete organization of the tribe, and presents the picture of a race without experience or external guide in an environment offering no hint that the putting of an extra covering upon the body would protect a person from cold. All progress in the art of living was brought to pass through man's power to think under the pressure of want. "And the people thought" was the prelude to every change, to every betterment of their condition. From this legend we discover that bodily covering was devised in order to satisfy a new want kindled through the awakening of self-consciousness.

The development of clothing depended upon the invention and use of implements. By means of tools skin dressing and sewing became possible and the manufacture of garments more or less elaborate.

The unfashioned hide used as the primitive garment, preserving as it did the semblance of the animal itself, in contributing to his comfort served also to increase man's confidence in the close relation he conceived to exist between himself and visible nature. Although in later times his ordinary clothing ceased to exemplify these close relations, yet when he entered upon sacred ceremonies there was a return to primitive forms in his apparel as best symbolizing his ideas. Various instances were cited to illustrate this statement.

Personal adornments worn by the mature man were of two kinds: those which referred to his totem, the concrete sign of his vision, the symbol of his personal relations to the supernatural, and those which indicated his personal achievements. These latter related to his deeds of valor, his war honors. Among the Omahas there were six regular honors to be won in battle. These were graded, and represented classes of deeds ranked according as they demanded courage for their performance. Among the highest in rank was that of striking the living enemy with the hand or bow; among the lowest was the taking of the scalp. Each of the six honors had its peculiar sign, shown in the painting of the face or body, or position of the feather worn in the scalp-lock, or both. The authority to use these decorations was publicly accorded the Omaha warrior in the rites pertaining to the sacred tent of war.

As the people advanced in the arts of living and life became more complex, the idea of making the dressed skin more subservient to the convenience and service of man found expression in the moccasin. In order to make this foot gear, it was necessary so to cut the skin that when the parts were sewed together all semblance of the animal was completely lost and the supernatural connection was broken. Thus the moccasin became typical of man as a social being, and played an important and exclusive part in certain ceremonies which laid stress upon social obligations. Several rites and customs were cited bearing upon the peculiar significance attached to the moccasin.

A further development of social ideas was shown by the ceremonies which attended the making of the Eagle feather war-bonnet, and also the war-shirt.

* Abstract of a paper read before the Boston (1898) meeting of American Association for the Advancement of Science.

As to the use of natural forms in regalia, all those so utilized had a peculiar significance, so that, when the Indian looked upon the robes and ornaments, or the sticks, the stones, the shells, the dead birds, he did not see these things as they looked to the eye of the stranger, for to his mind they suggested the mysterious powers which encompassed him. These natural forms he believed to be the channels through which supernatural forces were enabled directly to affect his life, to give him food, health, length of days, and children to perpetuate his race.

The fears inspired by the Indian's primitive ideas ceased to fill his mind with a vague dread so soon as the relations between him and his fellow men were formulated and his appeals to the supernatural relegated to particular times and seasons. Under the regulating influence of rites and ceremonies, and the growth of social order, mental bewilderment gave way and conditions arose favorable to the development of secular life, wherein the individual could find play for personal emotion, in the pose of his body, in his gestures and the adjustment of his drapery.

A number of lantern illustrations were given showing the unconscious adjustment of the robe or blanket in accordance with the varying mood or action of the wearer. These unique pictures substantiated the statement that the untutored attitude of the Indian, with his blanket wrapped about him, under the impulse of his passing emotion, told its story with a simplicity and truthfulness equal to that immortalized by classic art.

The essay closed with the following summary: "We have found the garment to have been an invention by which man's self-consciousness could be emphasized. Its practical uses were subservient to this primary purpose. We have noted that man's self-consciousness was born of attrition with his fellows, that his use of garments indicated not only the birth but the development of his conscious personality, that they expressed his relations to the unseen world, that they came to characterize his experiences and exploits, to mark his place and obligations in society, and finally his freedom in personal expression.

"This study of a people having no theoretic knowledge of psychical laws yields interesting evidence of the action of these laws, an action which seems to have so impressed the untutored man that he, as in the sacred legend and elsewhere, recognized that the directive force in his development was internal rather than external, was in his power to think and not in his environment; and that while he may not have discerned that his individual growth, for good or evil, depended upon his relations to other human beings, he acted in accordance with the psychical law that man can only achieve himself in the arena of society."

LIQUID AIR.*

LET us suppose ourselves to be transferred to the surface of the sun: instead of the atmosphere which now surrounds us, we should have an atmosphere composed of the vapors of iron, of zinc, and of other substances which we now know as metals and which exist here only in the solid state. In consequence, the rain which falls upon the sun's surface is an actually liquefied metal, condensed from the aeriform metal which forms the atmosphere surrounding the sun. What is the difference between the solar and the terrestrial states of the metal? Simply a question of temperature. If I raise the temperature of any solid substance sufficiently, I can convert it into a liquid or into a gas. In the same way, on raising the temperature of a liquid, it becomes gaseous; and, conversely, on lowering the temperature of a gas, it becomes a liquid. Finally, by lowering the temperature of a liquid, it becomes a solid.

There are to this rule no exceptions. By this I do not mean that there are no solids which cannot be converted into liquids. I would hardly be disposed to say, for example, that by any amount of heat you can convert bread into a liquid; for we all know that by subjecting bread to an unreasonable amount of heat we do not liquefy it, but we decompose it. So that I must limit what I have to say to undecomposable substances; i. e., to the elements. The chemist tells us that there are about seventy of these elementary substances, which he calls "simple matter." There is no reason to doubt then that under suitable conditions of temperature every single one of all the seventy elements can be changed from one into another of these three forms. Every single one of the elements can be obtained in the gaseous, in the liquid, and in the solid form. Why, then, should we be surprised that the air, which is a mixture of two of these elements (nitrogen and oxygen), can be converted into a liquid? Hence the discovery consists not so much in the fact that air can be converted into a liquid as in the method by which it can be so converted.

The question is a very simple, and historically, a very interesting one. That prince of experimenters, Prof. Faraday, was among the first to convert what are ordinarily called gases into the liquid form. In his laboratory in the Royal Institution, in London, he made his early experiments; and those experiments have been carried on by his successors until now the most magnificent results in the world have been obtained in this selfsame laboratory by Prof. Dewar, who has there liquefied not only the gases which Faraday liquefied, but all the other gases which we know. I stood in that laboratory only a short time ago and said to Prof. Dewar, "What do you suppose Faraday would say if he could walk into this room now?" In place of the little glass tubes which he used for the purpose of liquefying gases, the laboratory was filled with steam engines, compression pumps, and steel cylinders and bore the aspect of a machine shop. "What would he say?" replied the professor. "He would be the most delighted man in the whole kingdom. This is nothing but the following out of the path that Faraday pointed out, and in which he went as far as the knowledge of his time permitted." So it is in our scientific institutions; we seem to depart sometimes from the path of pure science; but this is only a seeming. There is no greater privilege accorded to man than that of standing face to face, for the first time, with a new fact in nature. He who has in his possession a fact which nature has revealed to him alone—a knowledge which hitherto the world has not known—has attained the highest possible human ideal. If we could only realize that out of this research, done quietly in the laboratory, have come all the wonderful advances which characterize the nineteenth century, I think we should be more willing than sometimes we are to build laboratories for research and to endow institutions in which such investigations may go on. If there is any one thing that characterizes the progress made in this present century, it is the tremendous development of physical science, made possible only by the application of truths discovered by physical research.

Water, when heated under confinement, becomes the aeriform matter which drives our steam engines and has thus made itself the master of the world. Cooled, it passes into the condition of ice. Ice heated above the zero point becomes a liquid; and that liquid, still further heated, becomes a gas. Faraday took ammonia gas, for example, and placed it in contact with chloride of silver, by which it was absorbed in enormous quantities. Then, by placing this in a bent glass tube, sealing the tube and heating the contents, the gas was again given out under an increasing pressure until finally, the tube being cooled in ice and salt, the ammonia gas became a liquid. In a similar manner he liquefied chlorine, sulphurous oxide, and a dozen others of the common gases. But he finally reached a limit. He subjected oxygen to a pressure of 1,000 pounds per square inch (subsequently increased by others to 4,000 pounds) without effecting its liquefaction. Hence, gases like oxygen were called permanent gases, because it was supposed they could not be liquefied.

In 1869, Dr. Andrews, of Belfast, discovered the important fact that, unless these gases be cooled to a very low temperature, it is impossible to liquefy them by any amount of pressure. Faraday's difficulty, then, was this: that he did not cool the gases far enough. If he had cooled oxygen, hydrogen, marsh gas, or any other of the so-called permanent gases to a sufficiently low temperature and then applied the pressure, he would have been able to liquefy it. The solution of this problem, therefore—the experiments of Andrews in Belfast having proved that all gases require to be cooled to a particular temperature before they can be liquefied—revolutionized the entire process for the condensation of gases and made it possible to liquefy them all. Below is given a table showing these temperatures, not only for the more familiar gases, but also for the so-called permanent ones.

CRITICAL CONSTANTS.

	Temperature. Degrees C.	Pressure. Atmospheres.
Hydrogen	—240	13·3
Nitrogen	—146	33
Carbon monoxide	—140	39
Oxygen	—119	50
Methane	—100	50
Nitrogen monoxide	—93	71
Ethylene	+10	51
Carbon dioxide	+32	77
Nitrous oxide	+53	75
Acetylene	+57	68

We have here acetylene, nitrous oxide, carbon dioxide, and ethylene, for example; which four gases have plus signs before the temperatures. To these temperatures, therefore, they must be cooled before they can be liquefied. The first on the list is acetylene, a gas which is just now a candidate for popular favor as a brilliant illuminant. The second is nitrous oxide (the so-called laughing gas). The third, carbon dioxide, is liquefied here in Philadelphia on a commercial scale for various purposes, principally (in consequence of the pressure it exerts) for making soda water and for forcing beer out of the cask. Then lastly we come to ethylene (called olefiant gas, because with chlorine it makes an oil known as the oil of the Dutch chemists). The temperatures for these gases are all plus quantities: ethylene, plus 10°; carbon dioxide, plus 32°; nitrous oxide, plus 53°; and acetylene, plus 57°. This means that unless we cool ethylene to 10° above zero, carbon dioxide to 32°, nitrous oxide to 53°, and acetylene to 57°, we cannot liquefy them. These are quite ordinary temperatures; and you notice that that given for ethylene is only a little below our winter temperature. Hence, Faraday was able to liquefy all these gases because the temperatures of liquefaction required for them are temperatures easily reached. But now we come to nitrogen monoxide—a familiar gas to the chemist; and we see from the table that it is necessary to cool this gas down to 93° below the zero of Centigrade in order to liquefy it. So when we come to marsh gas the required temperature is —100°; that of oxygen, —119°; of carbon monoxide, —140°; of nitrogen, —146°; and of hydrogen, —240°. Faraday never dreamed of obtaining any of these low temperatures; and yet that is the condition—that all these gases must be cooled down to these respective temperatures in order that they can be liquefied. These temperatures are called critical temperatures: they are the temperatures constituting the dividing line between the possibility of liquefaction and the non-possibility. We must subject the gas to cold and pressure; the cold required is the critical temperature; and the pressure required at the critical temperature is the critical pressure. The values of these pressure constants are given in the third column of the table above. As the critical temperature diminishes, the pressure increases; so that you will observe that these very high pressures—68, 75, and 77 atmospheres—are far greater than the others above them; so that it is clear that Faraday exerted pressure enough—one hundred times pressure enough—if he had only known that it was also necessary to cool these gases below the critical temperature. Any gas whatever may be liquefied if it be cooled enough; and as air is a mixture of nitrogen and oxygen, we have only to cool air down to the critical temperature of the mixture of these gases existing in the air in order to liquefy it.

Again, what determines the boiling point of a liquid? The boiling point of a liquid is defined to be the temperature at which the pressure of its vapor is equal to the pressure of the atmosphere. If, then, we were to take a delicate instrument and measure the pressure of the vapor, we should find that it would just equal the atmospheric pressure.

PROPERTIES OF LIQUEFIED GASES.

	Boiling Point. Degrees C.	Pressure at 15° C. Atmospheres.
Water	+100	0·021
Ether	+ 35	0·563
Sulphur dioxide	— 10	3·000
Cyanogen	— 21	4·000
Methyl chloride	— 24	4·000
Ammonia	— 38	7·000
Hydrogen sulphide	— 74	10·000
Carbon dioxide	— 80	52·000
Nitrous oxide	— 92	31·000
Ethylene	—103	42·000
Nitrogen monoxide	—153·6	....
Methane	—164	....
Oxygen	—180	....
Carbon monoxide	—190	....
Air	—191	....
Nitrogen	—193	....

Different liquids boil at various temperatures. Thus, for instance, as the table shows, water boils at plus 100° C.; ether at plus 35°; sulphur dioxide (the gas causing the smell from a burning match) at —10°; carbon dioxide at —80°; marsh gas or methane at —164°; nitrogen monoxide at —153°; oxygen at —180°; carbon monoxide at —190°; air at —191°; and nitrogen at —193°. These substances, therefore, actually boil at these exceedingly low temperatures; by which is meant simply that at these temperatures the pressure of their vapors becomes equal to the pressure of the atmosphere. Thus, for example, liquid air is boiling in that can under the pressure of the atmosphere. At what temperature? At —191° C., a temperature 320° below zero of the Fahrenheit scale.

I have often been asked, when boiling a liquid at a temperature far below freezing, "Is it hot?" You can burn, i. e., destroy, the tissue of your fingers at —191° C. as you can in boiling water at plus 212° F. Suppose, further, I take water and diminish the atmospheric pressure upon it; the definition still holds; the boiling point of water is always the point of temperature at which the pressure of its vapor is equal to, not now the atmospheric pressure, but the pressure actually exerted upon it; such, for example, as exists under the receiver of an air pump. If we assume that there is no pressure upon it, then at what temperature will it boil? At zero temperature; or, in other words, it will boil at any temperature at which it can remain liquid, so that in a good vacuum water will boil under a layer of ice. We see, then, that boiling and freezing may be simultaneous, the process being one depending solely upon the pressure. When I speak of liquid air as boiling, therefore, I mean simply that it has arrived at a point of temperature when the pressure of its vapor is equal to the external pressure exerted upon it.

What, now, is the density of these liquid gases? Density is defined as the weight of a given volume of a substance referred to that of water as the unit. If we liquefy nitrogen, we get a liquid which has a density of 0·850; if we liquefy oxygen, we have a liquid with a density of 1·124 (water, in both cases, being unity); so that oxygen is a little heavier and nitrogen a little lighter than water. If we mix these gases together, so as to get such a mixture as we have in air, the density of the liquid air is 0·910, thus showing liquid air to be somewhat lighter than water. Moreover, we can not only liquefy air, but we can freeze it; and this at about the temperature at which nitrogen freezes, which is 214° below zero Centigrade. If we exhaust the air from a surface of liquid air by putting it under the receiver of a vacuum pump, it will boil at a lower temperature, as we have just seen. But you say, "Is not the 191° below zero Centigrade low enough?" I say "No; nothing is low enough if we can get lower." We suppose the temperature of space to be —273° C., and the laws of thermodynamics teach us that that is practically the absolute zero of temperature, that no temperature can exist below that. The critical temperature of hydrogen is —240°, which is notably near that point. Even if we take liquid nitrogen or oxygen, and put it in a flask and connect this with an air pump so as to exhaust the air and thus diminish the pressure, it will boil at a lower and lower temperature as the pressure is diminished; so that in this way Prof. Dewar has been able to get a temperature of —240° from liquid air by simply placing it in a sufficiently high vacuum. If we could thus boil hydrogen under a reduced pressure, we should undoubtedly get a temperature very near the temperature of the absolute zero.

We are taught in our books on physics that air, when cooled, contracts $\frac{1}{273}$ of its volume for each degree of lowered temperature. Suppose we lower it 273°, thus cooling it to the absolute zero; then it will contract $\frac{273}{273}$ its volume. The arithmeticians may tell us how much of the air would be left. In fact, we seem to have annihilated the air; all our gases seem to disappear at that point. But this is impossible; and to find what would happen is the reason why we are anxious to get to the temperature of absolute zero.

The moment that Dr. Andrews announced that every gas must be cooled to a sufficiently low temperature before it could be liquefied, the truth of the proposition was recognized and soon after applied in practice. Pictet in 1877 first succeeded in liquefying oxygen, but by a very circuitous process. He first liquefied sulphur dioxide and then boiled that in a partial vacuum, thus obtaining a temperature very much below the critical point. The boiling point of sulphur dioxide at the normal pressure is relatively high, but at a reduced pressure very much lower. Then he cooled ethylene down by this boiling sulphur dioxide until a temperature was reached at which it liquefied. The liquid ethylene, placed in its turn in a vacuum, boiled at a lower temperature still, until finally he succeeded in reaching the critical temperature of the oxygen which it surrounded and liquefying it.

The chemist Cailletet solved the problem almost simultaneously, but by a different method. If a gas is allowed to expand against resistance, work is done and the expansion develops cold. You may remember an experiment with an ordinary air pump. Using a receiver on the plate and making a single stroke with the pump, we observe that the air in the interior be-

* Revised by the author. A lecture delivered at the Friends' Institute Lyceum, Philadelphia, by Prof. George F. Barker, of the University of Pennsylvania.

comes misty. That is due to the fact that the expansion of the air cools it and precipitates its moisture; and this precipitation of moisture in liquid drops illustrates the result obtained by Cailletet. In fact, this is the basis of the fundamental process now in use for liquefying air.

Prof. Dewar first took this matter up in 1883, using substantially Pictet's process. Ethylene is not an easy gas to make and is a difficult one to condense. Hence to see standing in the Royal Institution a dozen steel cylinders full of liquid ethylene, prepared under the direction of Prof. Dewar, was quite as much of a marvel to me as anything else I saw there. All this had to be done, however, in order to get the liquid oxygen.

(To be continued.)

STANHOPEA MADOUXIANA.

I RECEIVED from M. Florent Claes materials which enabled me to study this new species at the same time and in the same way as was the case with S. Rodigasiana. The pseudo-bulbs are ovoid, covered with scales, which at the point are all fringed into narrow filaments; they are surmounted by a leaf which is erect, full, rather stout, oblong, sharply pointed, with five distinct veins, of a deep green color, attaining from 20 to 30 inches in length by from 5 to 9 inches across, furnished with a long and slender petiole. Peduncle pendent, long, rather robust, flexible, biflorous or sometimes uniflorous. Bracts rather large, swelled, oval, obtuse. Flowers deliciously fragrant, from 5 to 7 inches across, lasting about three days. Sepals triangular-oval, obtuse, convex, of a cream white color, evenly covered with large spots of carmine rose much raised toward the peduncle after the second day from the opening of the bloom. Petals widely oblong, obtuse, convex, with very delicately waved edges, a little shorter than the sepals, of the same color as they, and raised like them toward the peduncle. Lip fleshy, nearly as long as the sepals, of the same color as the other parts of the flower, except the cavity of the hypochile, which is deeply tinged with violet-black; hypochile long, cymbiform, much incurved, and a little dilated in the upper part, without appendices; mesochile bearing two fleshy horns, pendent, ligulous, pointed, slightly arched; epichile the size of the horns, oval, pointed a little, convex. Column as long as the lip, rather incurved,

STANHOPEA MADOUXIANA.

nearly semi-cylindrical in the lower portion with two rather large wings in the upper part. This beautiful species, which seems somewhat to resemble S. oculata, Ldl., was obtained by M. Claes in the Province of Antioquia (Colombia).—A. Cogniaux, in The Gardeners' Chronicle.

THE WORLD'S COPPER PRODUCTION AND CONSUMPTION.

THE world's copper consumption is increasing at a very rapid rate, as is shown in the following estimate by Messrs. Aaron Hirsch & Son, of Halverstadt:

	Metric tons.				
	1893.	1894.	1895.	1896.	1897.
Germany	60,513	62,955	70,349	85,371	96,385
France	33,989	31,837	40,393	49,007	58,336
England	99,615	90,069	91,084	115,557	110,210
Austria-Hungary	14,901	16,457	15,725	16,498	18,288
United States	77,443	94,511	108,000	92,698	101,404
Totals	283,348	295,829	325,491	359,131	394,652
World's production	309,580	324,505	334,565	373,063	399,728

The last line of figures gives the world's production as estimated by Messrs. Henry Mason & Company. The English consumption of copper is still greater than that of any other country, while their percentage of the world's production is constantly decreasing. The United States now supplies 54 per cent. of all the copper produced in the world.

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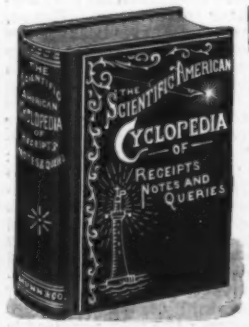

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